ELECTRICITY FORECASTING FOR THE SMALL SCALE POWER SYSTEM USING FUZZY LOGIC

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ELECTRICAL & ELECTRONICS ENGINEERING
UNIVERSITI TEKNOLOGI PETRONAS
JUNE 2010

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DISSERTATION

Submitted to the Electrical & Electronics Engineering Programme

in Partial Fulfillment of the Requirements

for the Degree

Bachelor of Engineering (Hons)

(Electrical & Electronics Engineering)

Universiti Teknologi PETRONAS,

Bandar Seri Iskandar,

31750 Tronoh,

Perak Darul Ridzuan

June 2010

CERTIFICATION OF APPROVAL

Electricity Forecasting for the Small Scale Power System Using Fuzzy Logic

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Siti Sarah binti Md Yunus

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(ELECTRICAL & ELECTRONICS ENGINEERING)

Approved by,

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TRONOH, PERAK
JUNE 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(Siti Sarah binti Md Yunus)

ABSTRACT

Electricity supply to Universiti Teknologi PETRONAS (UTP) comes from gas district cooling (GDC) plant as a primary source of energy and TNB as a backup. With a maximum capacity of 8.4MW which comes from 2 nos of gas turbine generator rated at 4.2MW each, this project aims to forecast short term electricity demand of the plant. As a sole customer of the plant, UTP 2008 electricity demand data is being used as a basis to design a forecasting model with using Fuzzy Logic (Fuzzytech Software). With the forecasting model, it will help GDC (UTP) for pre-planned scheduling and maintenance of the plant and also can be a good guidance for their daily operation of the plant.

ACKNOWLEDGEMENT

All my praise and greatest thanks to Allah for I was given the time, chance and courage to complete my Final Year Project. Thanks to Him, I had the ideas and strength to complete my thesis which comprises of my hard work of one year.

I would like to express my foremost gratitude to my supervisor, Mr. Zuhairi bin Hj Baharudin for his valuable guidance and support throughout the progress of the project. Being under his supervision has been beneficial; his advice, knowledge and experience of the project, has tremendously helped towards the completion of my Final Year Project. I would like to thank him for the time spent for consultation and all the knowledge shared.

The deepest appreciation goes to my co-supervisor from Maintenance Department, Ir. Mohd Fatimie Irzaq bin Khamis. I would like to thank him for providing me all the data needed for the project as well as for the brilliant ideas towards enhancing the project to its maximum. Without his continuous guidance and help, the project would have not been completed with ease.

I would also like to thank the lab technician, Madam Siti Hawa binti Mohd Tahir for helping me to use the lab facilities and the all the guidance she gave all the way towards completing the thesis.

My extended gratitude goes to my family members and friends. Thank you for all the support and strength, knowledge shared and for everything you have done for me. There are others to thank, whom I did not mention their names, but their contribution is extremely valuable. Only God can repay all of your good deeds.

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ABBREVIATIONS

ANN	Artificial Neural Network
ARMA	Auto Regression and Moving Average
DDE	Dynamic Data Exchange
DOS	Degree of Support
FAM	Fuzzy Associative Map
GDC	Gas District Cooling
GTG	Gas Turbine Generator
MAPE	Mean Absolute Percentage Error
kW	kilo-Watt
LTLF	Long Term Load Forecasting
MTLF	Medium Term Load Forecasting
MW	Mega-Watt
STLF	Short Term Load Forecasting
TNB	Tenaga Nasional Berhad
UTP	Universiti Teknologi PETRONAS

CHAPTER 1

INTRODUCTION

1.1 Background Study

Prediction of future events and conditions is called forecast, and the act of making such predictions is called forecasting [1]. Electricity forecasting stands for the act of making prediction of future electricity using certain methods that take into account several factors that may affect the forecast. Electricity forecasting has been an integral part in the efficient planning, operation and maintenance of a power system [2]. Electricity forecasting can be divided into three categories, which are short term load forecasting (STLF), medium term load forecasting (MTLF) and long term load forecasting (LTLF). The load prediction may be a month or a year for the long term and medium term load forecast, and a week or a shorter period than a week for the short term load forecast. [3]

The need and relevance of forecasting demand of electricity has become a much discussed issues in the recent past. This has led to the development of various new tool and methods for forecasting in the last two decades [4]. The methods used are trend method, time series, end use method, linear regression, exponential smoothing, stochastic process, ARMA models, and data mining [4]. However, these methods are not reliable since it does not deal with the complexity of the electricity itself. An appropriate method is chosen based on the nature of data available and the desired nature and level of detail of forecast [4].

The trend method expresses the value of the electricity forecasted purely as a function of time. Though it is easy to use, the method does not include the other probable factors such as economic, demographic and weather factors, which are considered important for electricity forecasting. The time series method is defined to be an ordered set of data values of a certain variable. The intuition underlying time series processes is that the future behaviour of variables is related to its past value with some adjustment built in to take care of how past realizations deviated from those expected [4]. The use of artificial neural network (ANN) is widely employed for electricity forecasting lately. However, there exist large forecast errors using ANN when there are rapid fluctuations in load and temperatures [2]. Hence, a method that deals with the rapid fluctuations in load and temperatures needs to be employed in forecasting the future electricity demand.

1.2 Problem Statement

1.2.1Problem Identification

The electricity demand is a complex matter, making it hard to predict. There is suggestion that demand is fluctuating and part of a business cycle. There will be periods when there is stability and other periods of demand fluctuation. These cycles are linked to broader economic and business changes and not a trend that will continue ad infinitum [5].The load has complex and non-linear relationships with several factors such as climatic conditions such as temperature and humidity, past usage patterns, the day of the week, and the time of the day[6] .The assumptions are that the electricity demands are variable, seasonal especially for four seasoned countries, weather influenced, and time influenced and according to customer classes. Since the electricity demand is complex and non linear, a method that deals with it complexity should be used to forecast the future electricity demand. The Fuzzy Logic is a suitable choice since it deals with the complexity and non linear part of the power system and is able to deal with the abrupt change of weather variable such as temperature and humidity. The ability of the fuzzy logic in dealing with the qualitative and quantitative values makes it the best method to be used to forecast the future load of UTP demand.

1.2.2 Significance of Project

a) Formulate the Forecast Model

The forecast model is formulated with the goal of minimizing the MAPE as low as possible. This is due to lower MAPE will result in more accurate electricity forecasting. The model is formulated using the previous week's data. The inputs taken are the ones that might affect the forecast such as previous week load, day type, semester type and the temperatures. Using Fuzzytech software, the model is built using stated inputs and electricity forecast can be done using this model.

b) Study the electricity demand behaviour

The electricity demand data for UTP is collected from GDC. By plotting the daily electricity demand, the pattern and behaviour of the UTP's electricity consumption can be analyzed. Usually, the electricity demand behaviour is different for different type of days and semester. It is also affected by the temperature. For example, public holiday would give lower value of demand compared to a normal day. During semester break, the electricity demand is significantly reduced to a lower value.

c) Forecast the electricity demand

Using the data collected from GDC, the electricity demand can be forecasted. An appropriate model that takes into account the factors affecting future load is used to forecast the future demand. The IF-THEN rules specified in the rule block will determine the value of the electricity forecasted. The MAPE for each day is then computed so that the model evaluation can be made. Average prediction error, describing the accuracy level of power demand forecast technique, is about 1% and maximum error about 8% [7].

1.3 The project objectives

The objectives of the project are as follows:

- To analyze and study the principle of Fuzzy Logic
- To develop and design an accurate Fuzzy Logic model that can be used to forecast the future load in UTP
- To forecast the future load in UTP

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Introduction to Fuzzy Logic

Fuzzy Logic is not a logic that is fuzzy; instead it is a logic that is specially designed to mathematically represent uncertainty and vagueness [8]. It is derived from fuzzy set theory to deal with reasoning that is approximate rather than precise [8]. Fuzzy Logic is developed by Lotfi A. Zadeh in 1965 in his seminar paper entitled Fuzzy Sets. The logic is developed because of the thought that the classical control theory had put too much emphasis on precision, thus could not handle complex system. Fuzzy logic has been applied to various fields, ranging from control theory to artificial intelligence.

The objective of Fuzzy logic is to put human knowledge into engineering systems in a systematic, efficient and analyzable order. In contrast to binary sets that having binary logic (crisp logic), the fuzzy variables may have memberships values of not only 0 or 1. The values vary from 0 to 1, for example 0.2, 0.65, and 0.9. The difference between binary sets and fuzzy logic are as follows [9]:

Let X - the universe of discourse; its elements are denoted as x

i. Crisp set A is defined by the characteristic function
   $\mu A(x): X \rightarrow 0, 1$

ii. Fuzzy set A is defined by the membership function
   $\mu A(x): X \rightarrow [0, 1]$
   where:

$\mu A(x) = 1$

if x is totally in A

$\mu A(x) = 0$ if x is not in A

$0 < \mu A(x) < 1$ if x is partly in A

The previous example shows the fuzzy logic with a numerical value. The fuzzy logic usually is applied for the non numeric linguistic variables. It is often used for facilitating the expression of rules and facts.

The Fuzzy Logic uses IF-THEN rules which employ the linguistic variables (fuzzy variables) whose values are in the linguistic terms. The rules are usually expressed in the form of [9]:

IF variable IS property THEN action

For example:

IF temperature IS very cold THEN stop fan
IF temperature IS cold THEN turn down fan
IF temperature IS normal THEN maintain level
IF temperature IS hot THEN speed up fan

There is no ELSE term, since the temperature might be cold and normal at the same time to different degrees [9].

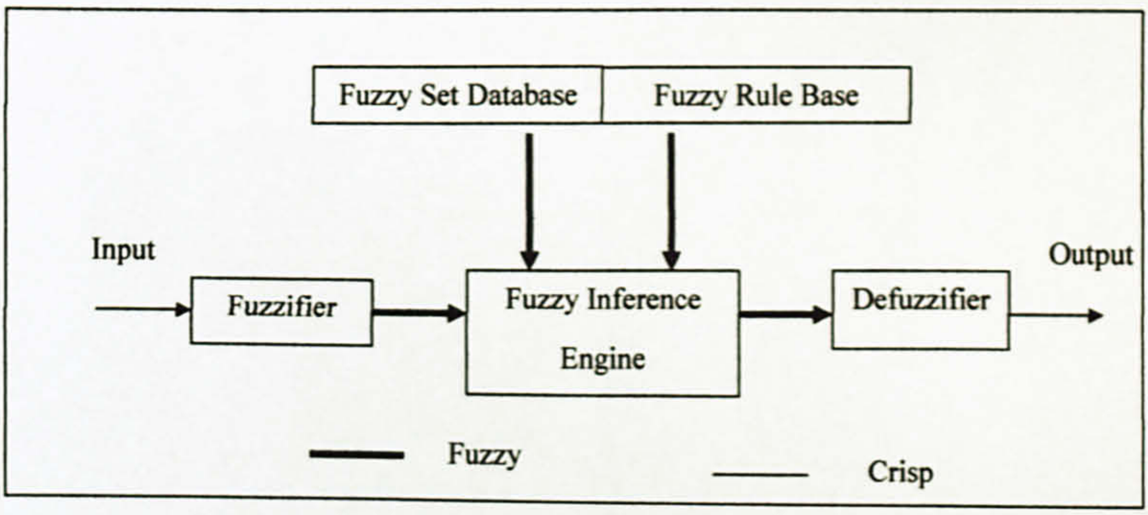

Figure 1 Basic Fuzzy Logic Configurations [10]

2.2 Fuzzy System Modelling

The modelling of the electricity load demand forecasting involves a few steps as depicted in the next diagram as follows:

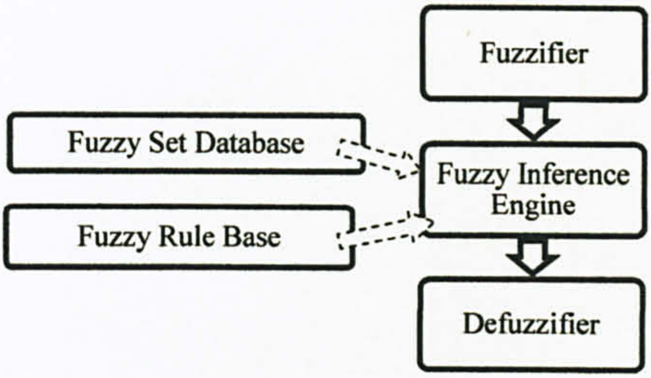

Figure 2 Modelling Steps of Fuzzy Logic

The modelling starts with user entering the inputs. The inputs are in terms of the crisp value. The Fuzzifier will then transforms the real valued input variables into fuzzy values. Next, the Fuzzy Inference engine will map the fuzzy inputs earlier to the fuzzy output based on the Fuzzy Rules. The Fuzzy Rules and Fuzzy Set Database are entered by the user to enable the inference engine to function properly. Finally, the defuzzifier will transform the fuzzy outputs into a real valued output so that analysis can be done.

The term membership functions are defined as the degree to which a crisp value belongs to linguistic value of the linguistic variable. This membership degree is represented by a value in the range of 1.0 and 0.0. A Membership degree of 0.0 means no membership at all, a degree of 1.0 means it is an absolute membership. [13]. There are various types of MF are Triangular, Trapezoidal, Gaussian and Sigmoidal.

2.3 Fuzzytech Software [11]

The Fuzzy Tech Edition 5.5b software is used extensively in this project. The Fuzzy Tech software is used to apply the Fuzzy Logic Technique. There are four steps in performing the Fuzzy Logic application, which are;

i. Identifying input and output variables
ii. Establishing the IF-THEN rule blocks
iii. Fuzzification and Defuzzification
iv. Analyzing outputs obtained

The Fuzzytech software also supports advance inference method, which is the Fuzzy Associative Maps (FAM) inference. Using FAM, each rule is assigned a degree of support (DoS) that represents the individual importance of the rules. Rules in this term are also of fuzzy value, which ranging from 0 to 1 value. The validity of a conclusion is calculated by a linking of the validity of the entire condition with the DoS by a composition operator. Different DoS value will indicate different significant level of the rule on the output or the results.

2.4 Background of GDC

UTP electricity supply come from GDC (UTP) with a full capacity of 8.4 MW as a primary source of energy and TNB as a backup. Co-generation/District Cooling Plant (GDC) for Universiti Teknologi Petronas (UTP) is designed to produce electrical power and steam from Co-generation system (Cogeneration plant) and chilled water from chilled water system (District Cooling Plant). GDC has two gas turbine generators (GTG), which is capable of supplying enough electricity demand to the whole UTP. The maximum capacity of each generator is 4.2 MW. Both of the generators are being utilized to cater the UTP electricity demand. However, if the electricity demand is low enough, where demand is lower than 4.2 MW, then only one generator will be used. The other one will act as the backup generator. The power supply from TNB is only utilized in the case of emergency only.

CHAPTER 3

METHODOLOGY

3.1 Procedure

The methodology involves in this project includes a few steps. The following flow chart shows the overall view of the steps taken for realizing this project.

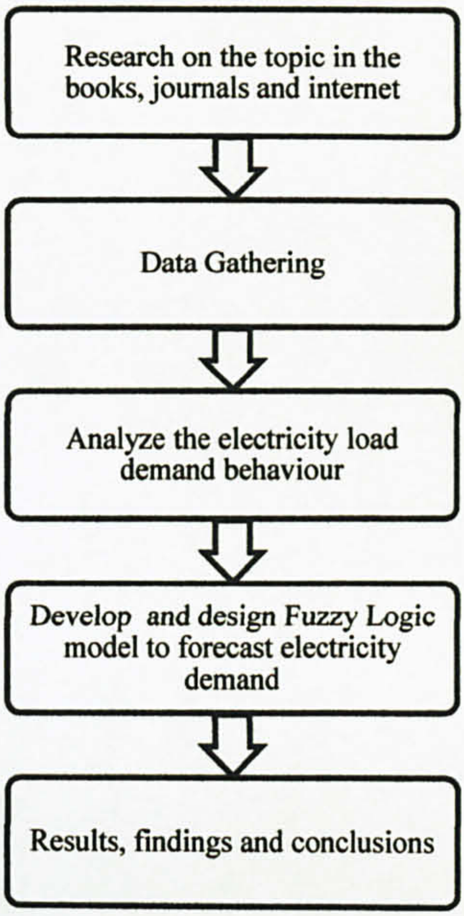

Figure 3 Methodology of Final Year Project 1 and 2

The method used for forecasting the load demand in UTP is Fuzzy Logic. The daily load demand historical data from GDC (UTP) is collected for the period of four years which is from 2006-2009 and the load profile is then studied and analyzed. Based on the analysis of the load pattern, a load forecasting model is then developed using Fuzzy Logic technique. The fuzzyTech software is used extensively in the project for modelling, modification and analysis of the load profile in order to predict the load demand accurately.

Based on the daily historical electricity load data and the load data established, it is found out that the latest data is more relevant to be considered to forecast the future load of UTP. This is due to the latest data of 2008 and above has already considered the electricity consumption of new loads such as the Undercroft and so on. In this project, the electricity load demand forecasted is for January 2009 semester, starting from the first week of the semester on until the last week of semester break.

3.2 Tools and Software

Fuzzytech Software is used extensively in the project. It applies the fuzzy logic application in the software. The following flow chart shows the modelling process using the fuzzyTech software.

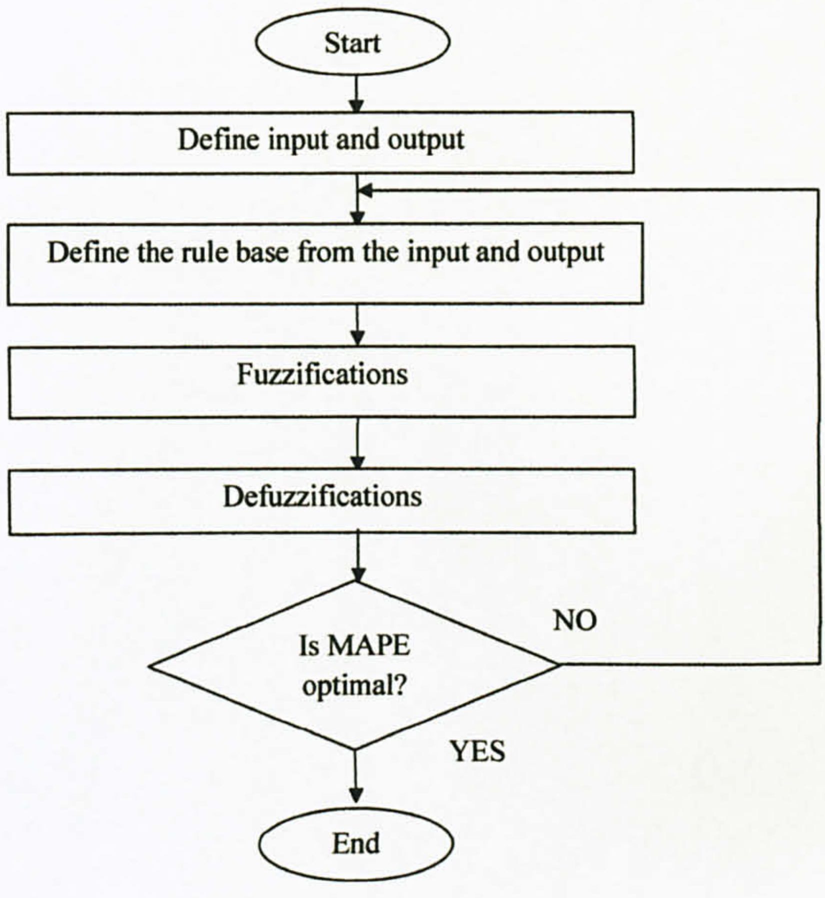

Figure 4 Process Flowchart of Modelling Using fuzzyTech

Using the fuzzyTech software, a process called fine tuning needed to be executed. The fine tuning process is a trial and error process, that is repeated during simulation until an optimal results or an accurate model is obtained. The fine tuning involves the process of specifying and editing the IF-THEN rules as well as the DOS. The procedure of the fine tuning process is as depicted in the next figure.

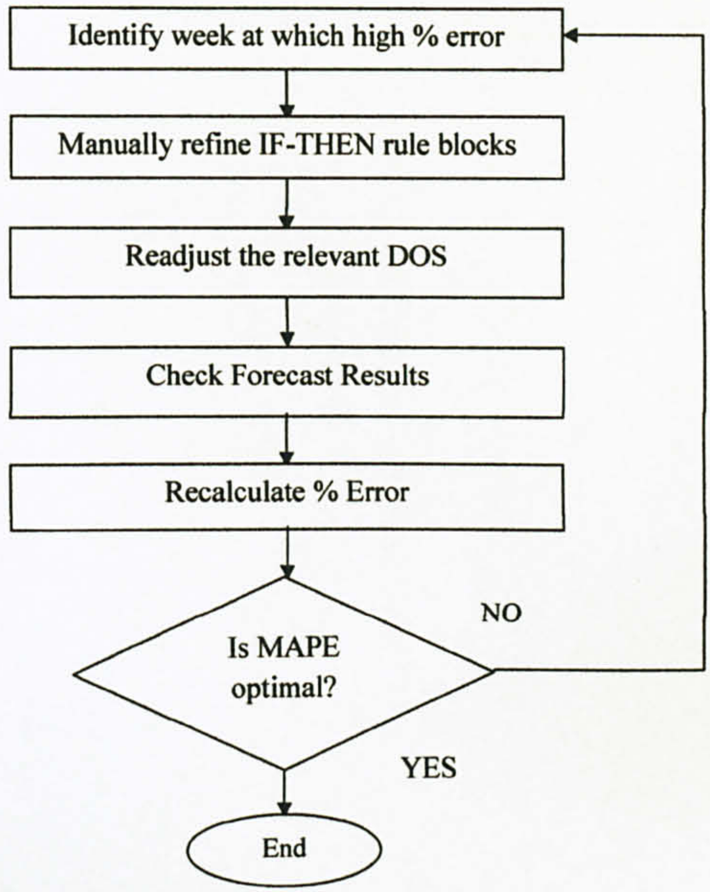

Figure 5 Process of fine tuning using fuzzyTech

The resulting forecasted data after each stage of fine tuning is then justified by evaluating the forecasting error present to the actual load. The other analysis includes calculating the absolute error. Larger error indicates a poor model design with a low accuracy. The errors are calculated using the formula as follows:

$$\% \text{ Relative Error} = \frac{\text{Forecast load} - \text{Actual load}}{\text{Actual load}} \times 100\% \qquad 3.1$$

$$\% \text{ Absolute Error} = \frac{|\text{Forecast load-Actual load}|}{\text{Actual load}} \times 100\% \qquad 3.2$$

As for the % Relative Error, a positive value of error will indicate an over forecast, means that the forecasted load is larger than the actual load. A negative value on the other hand indicates under forecast, where the forecasted load value is less than the actual value. The fine tuning process must be repeated until a satisfactory MAPE is achieved.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Analysis of Historical Data

The daily electricity consumption of UTP data from September 2008 until December 2008 is tabulated in Table 1-4 in Appendix A. From these data, the monthly load patterns for each month are plotted for analysis. This is to investigate the pattern and behaviour of the electricity consumption of UTP, so that it is easy to forecast the electricity for the next year.

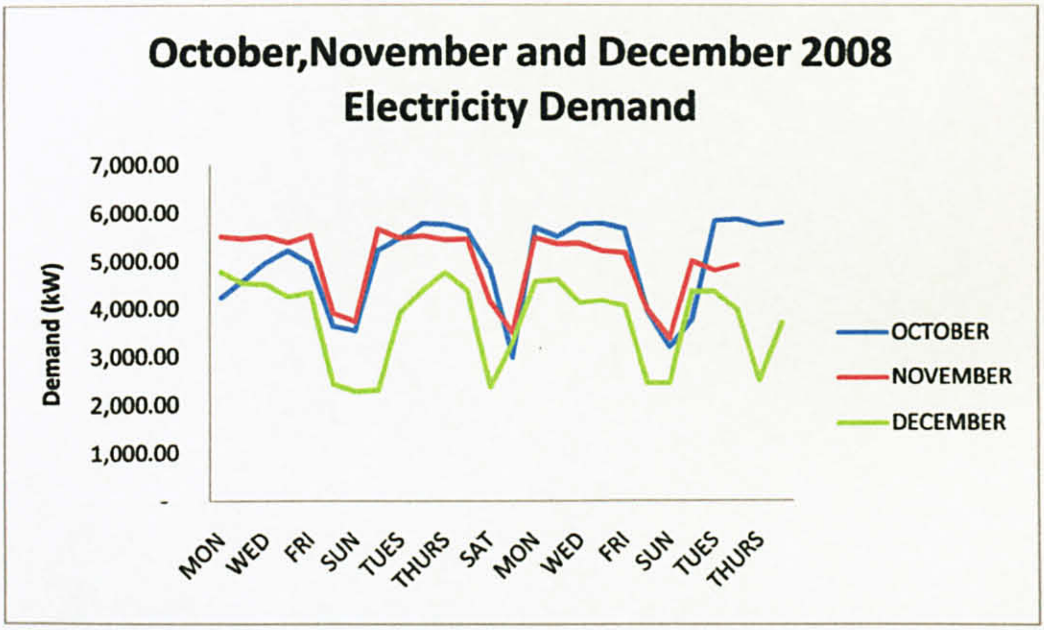

Figure 6 Electricity Demand from October-December 2008

From the above plots it can be seen that the trends of the three months are all the same. The weekdays consumed more electricity compared to weekends. Other than that, it is observed that the semester break which is in December gives significant smaller values of electricity demand compared to the semester on. However, the trends are still the same, which is weekdays consumed more electricity compared to weekends.

During semester break, most students are not in available in campus, but other staff are still on duty. Other than that, there might be postgraduate students and foreign students who did not go back for the semester break. The demand of the working day which is weekdays is usually higher although in the semester break and the trend is still the same. The effect of semester break to the electricity demand can be represented in the next graph.

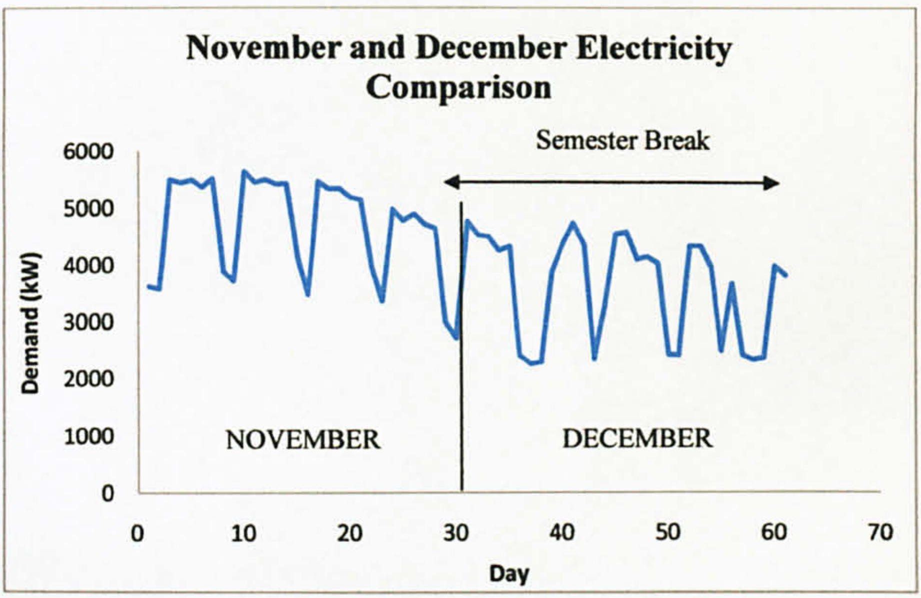

Figure 7 Effect of Semester Break to Electricity Demand

Notice that the electricity demand gradually reduced starting 22 November 2008. Although the official semester break starts on 29th November, most students have already finished their final exam and leave the campus. After 29 November until 30 December, the demand pattern is similar to the November plots, but the values are significantly reduced.

The weather factors such as temperature also affect the electricity consumption. Low temperature gives lower consumption while high temperature gives higher consumption of electricity. For example, if it is raining, the temperature would reduce to certain degrees where the fan or air conditioner would be slowed down or turned off. The following two figures show the effect of temperature to the electricity consumption of UTP.

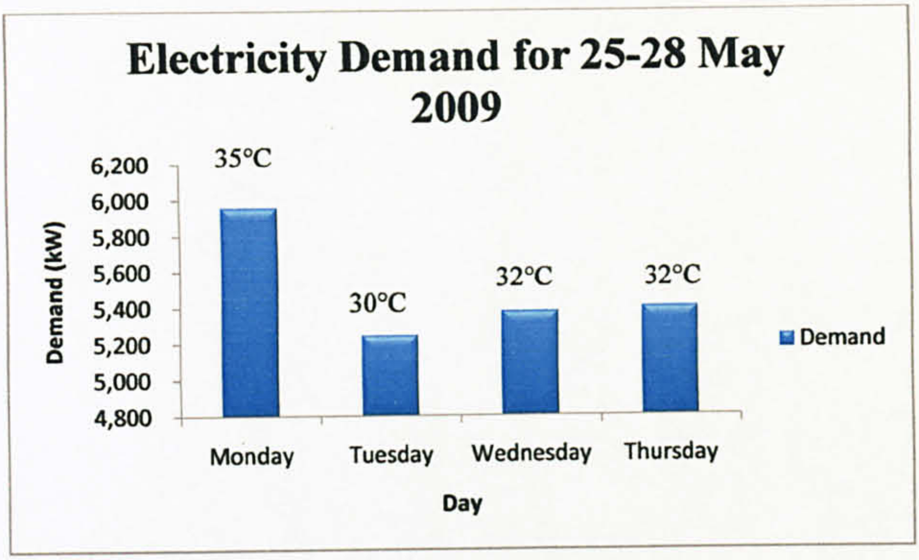

Figure 8 Effect of Temperature on Electricity Load Demand

The figure shows that higher temperature gives higher electricity consumption. This is clearly seen that when the temperature rise to 35°C, the electricity demand increased to more than 5900kW. When the temperature is stable, around 30-33°C, the electricity demand is also stable, ranging from 5200 to 5400 kW.

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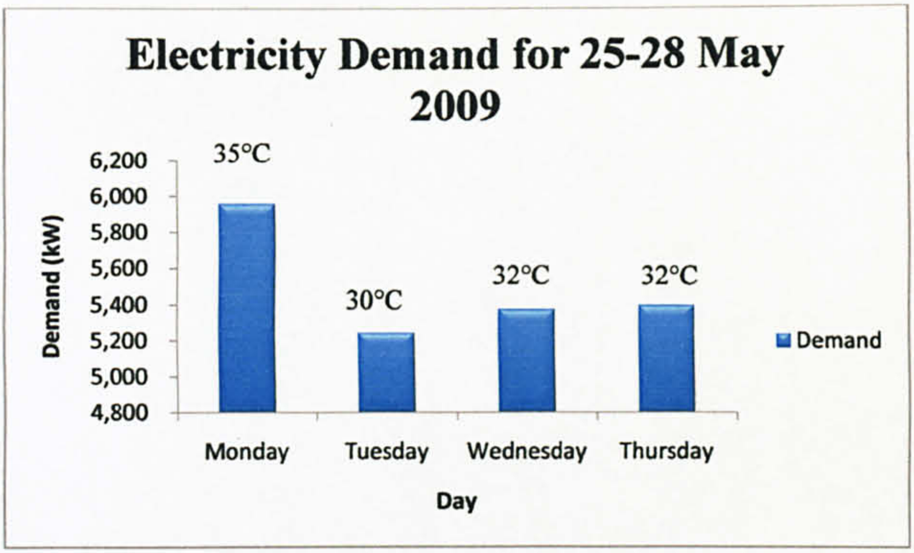

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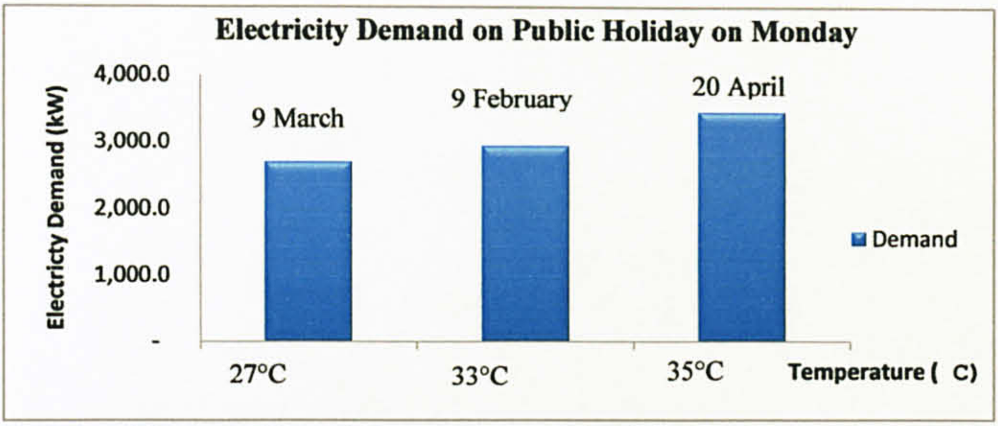

Figure 9 Effect of Temperature on Electricity Load Demand on Public Holiday

The above figure shows the electricity demand for public holidays that fall on Monday in January 2009 semester. Since it is public holiday, the electricity demand is significantly reduced to 2500 kW to 3500 kW. However, notice that the lower the temperature, the lower the demands are.

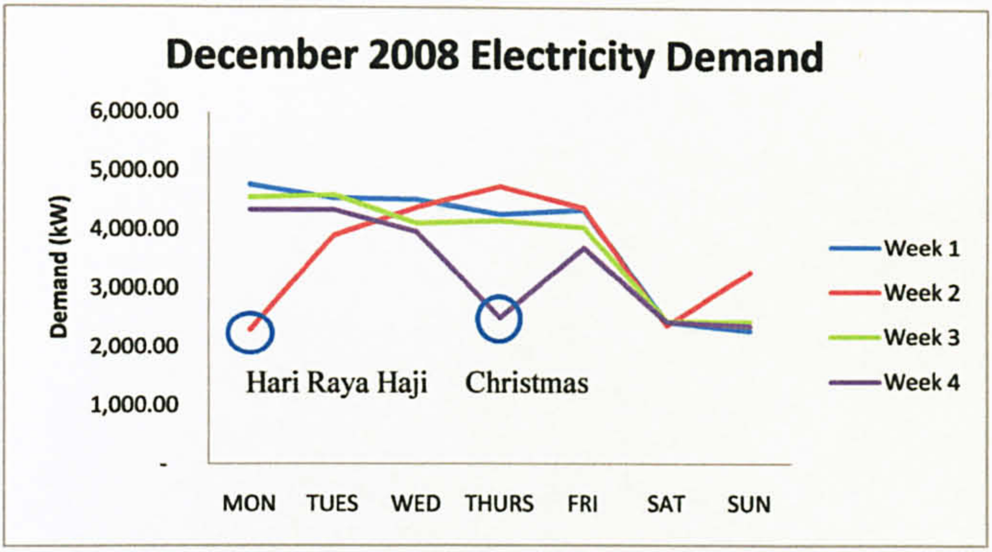

Figure 10 Effect of Public Holiday to Electricity Demand

The 8th and 9th December 2008 was the Hari Raya Haji Holiday. Since it is a public holiday in the semester break, the electricity demand value is significantly small. The same goes to Christmas holiday on the 25th. It can be concluded here that the public holidays give a lower electricity demand compares to the normal day, regardless whether it is during the semester or during semester break.

4.2 Forecast Analysis and Discussions

4.2.1 Model Used

The forecast model used is a week ahead electricity forecasting. The model used is quite complex compared to the one used in Final Year Project 1 but it makes forecasting work simpler.

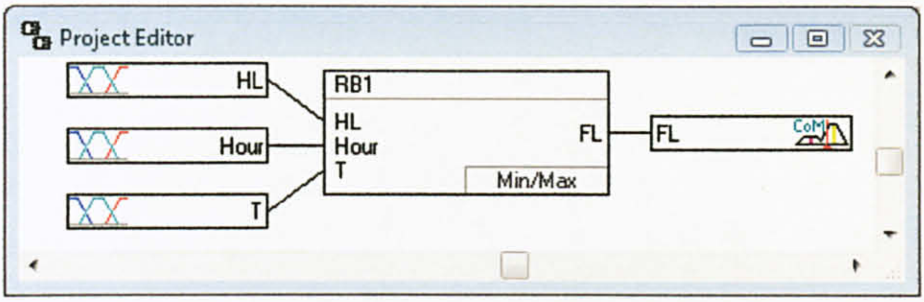

Figure 11 First Model Used

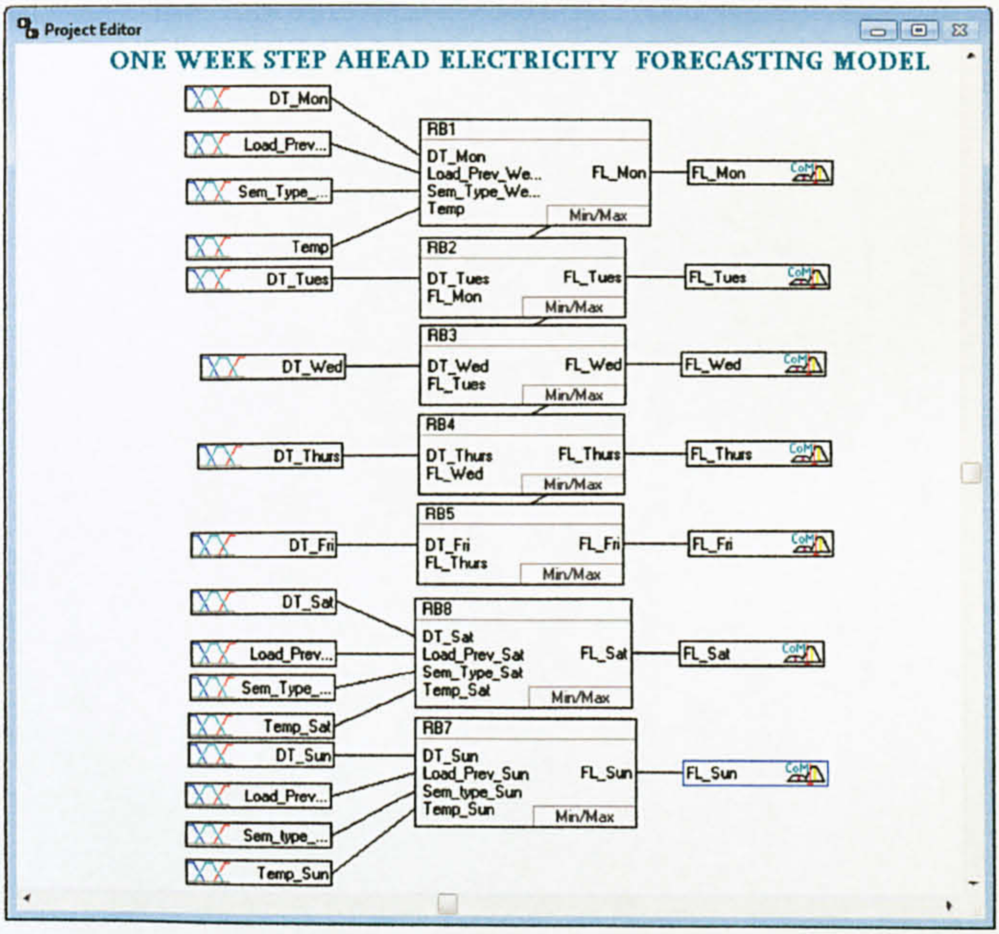

Figure 12 Latest Forecasting Model Used

This is due to the capability of this model to forecast the electricity for one week, compared to previous model which can only forecast for the next day. Other than that, it includes a few improvements that are in terms of inputs that may affect the forecast value. The inputs added that are considered important are the day type and the semester type. The other inputs are the average of weekdays of previous week, maximum temperature of the forecasted weekdays, Saturday and Sunday. Then there are Saturday and Sunday's previous week's electricity demand as the inputs to forecast for both days.

Since the behaviour of the electricity demand of weekdays and weekends are different, for the first five days, which is from Monday to Friday, the average of the previous week weekdays are taken as the input for forecasting. However, for forecasting electricity of Saturday and Sunday, the inputs taken are for both days. This is due to the difference of GDC electricity producing activity.

The day type is considered important as it gives significant fall for the electricity demand values. As depicted in the Figure 10, the public holidays make the pattern of the demand off-tuned compared to the normal days. However, special occasions such as convocation will give significant rise to the electricity demand.

4.2.2 Dynamic Data Exchange (DDE)

The dynamic data exchange is used to ease the results simulation. DDE link interface is created from fuzzyTech to Microsoft Excel. The DDE requires the user to enter the necessary inputs so that the output can be forecasted. The DDE for the latest model used is as follows:

Insert previous weekdays average load		kW
Insert forecast weekdays average maximum		°C
temperature		
Insert semester type of week to		
be forecast		
Insert forecast Monday day type		
Insert forecast Tuesday day type		
Insert forecast Wednesday day type		
Insert forecast Thursday day type		
Insert forecast Friday day type		
Insert forecast Saturday semester type		
Insert forecast Saturday day type		
Insert forecast Saturday's forecasted maximum		°C
temperature		
Insert previous week Saturday load		kW
Insert forecast Sunday semester type		
Insert forecast Sunday day type		
Insert forecast Sunday's forecasted maximum		°C
temperature		
Insert previous week Sunday load		kW

Figure 13 DDE

DDE Link Guide

- **Day Type**
  - Insert 1 for Public Holiday
  - Insert 2 for Normal Day
  - Insert 3 for Special Day
- Semester Type
  - Insert 1 for Semester Off/Break
  - Insert 2 for Semester On

4.3 Results Obtained

The model created is used to forecast the electricity demand for the whole semester of January 2009. The overall result will then be tabulated weekly. For example, the for January 2009, the first Monday falls on the fifth day, so the 1st January up till the 4th is forecasted using the 2008 data. The forecasting result is considered good if the MAPE obtained is less than 8 %. The results obtained are as follows:

Table 1 Forecasted and Actual Electricity Demand for Week 1

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
1	5,361.00	5,120.00	241	241.00	4.71	
	5,388.80	5,396.00	-7.2	7.20	0.13	
	5,700.00	5,414.00	286	286.00	5.28	
	5,544.40	5,382.00	162.4	162.40	3.02	
	5,488.80	5,140.00	348.8	348.80	6.79	
	3,866.65	3,638.00	228.65	228.65	6.29	
	2,500.00	2,488.00	12	12.00	0.48	3.81 %

- Chinese New Year Holiday

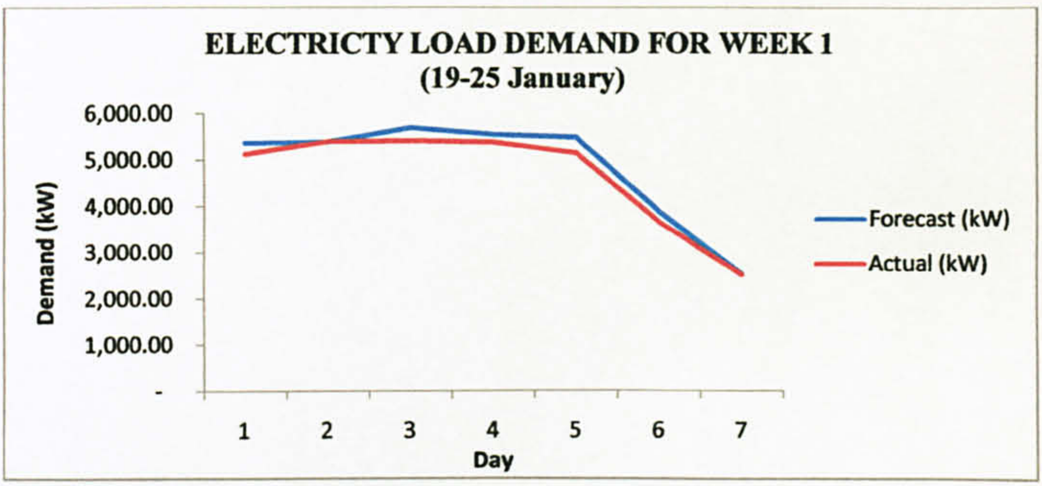

Figure 14 Forecasted and Actual Electricity Demand for Week 1

The MAPE obtained for the first week is quite low since the load demand is constant throughout the week. Since Sunday of the week is a public holiday which is the Chinese New Year holiday, the load forecasted is lower compared to a normal Sunday.

Table 2 Forecasted and Actual Electricity Demand for Week 2

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
2	3,064.50	2,932.00	132.5	132.50	4.52	
	2,722.20	2,752.00	-29.8	29.80	1.08	
	5,066.70	5,348.00	-281.3	281.30	5.26	
	5,216.40	5,662.00	-445.6	445.60	7.87	
	5,176.00	5,156.00	20	20.00	0.39	
	4,179.15	4,386.00	-206.85	206.85	4.72	
	3,200.00	3,068.00	132	132.00	4.30	4.02 %

-Chinese New Year Holiday

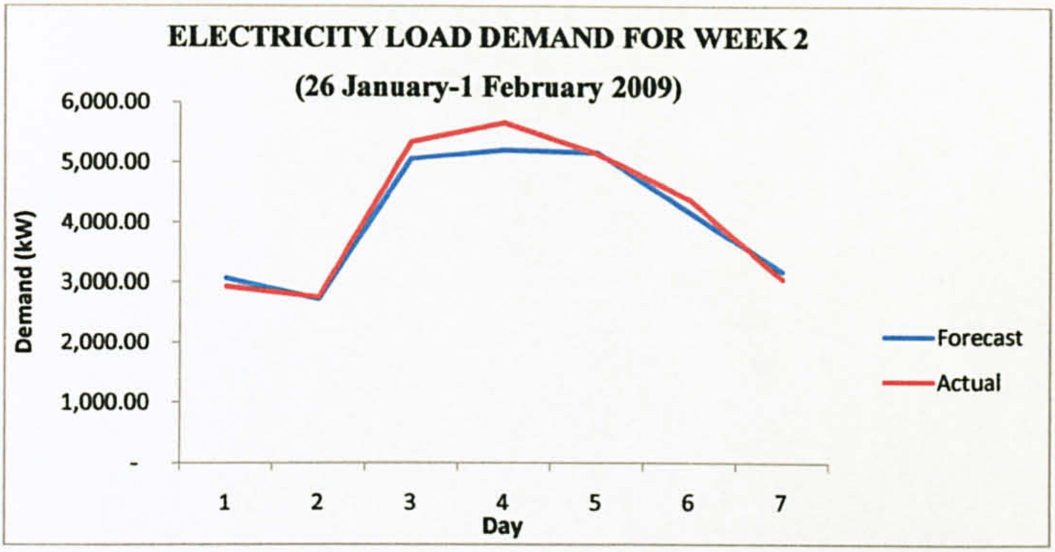

Figure 15 Forecasted and Actual Electricity Demand for Week 2

The continuation of the Chinese New Year Holiday on Monday and Tuesday gives significant fall of the electricity load demand value. The other days seem to have constant electricity load demand, and the MAPE obtained for Week 2 is 4.02 %, which is within the allowable range.

Table 3 Forecasted and Actual Electricity Demand for Week 3

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
3	5,133.30	5,204.00	-70.7	70.70	1.36	
	5,166.60	4,080.00	1086.6	1,086.60	26.63	
	5,488.90	5,376.00	112.9	112.90	2.10	
	5,544.40	5,256.00	288.4	288.40	5.49	
	5,488.80	5,124.00	364.8	364.80	7.12	
	3,727.75	3,676.00	51.75	51.75	1.41	
	3,200.00	3,256.00	-56	56.00	1.72	6.55 %

-Thaipusam Holiday

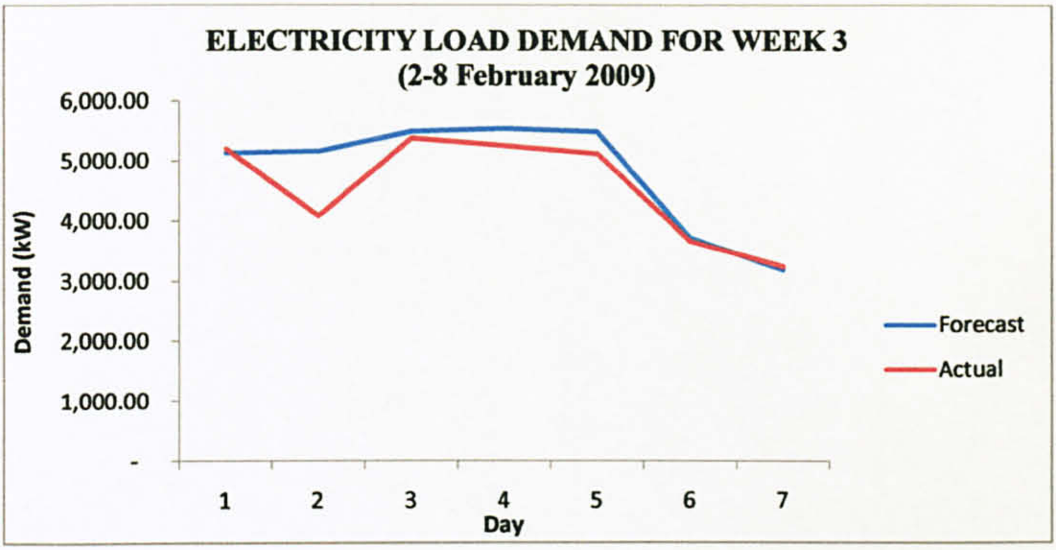

Figure 16 Forecasted and Actual Electricity Demand for Week 3

The electricity load demand for the 3rd week is stable except for Tuesday. Although there is no public holiday or special events recorded on that day, the load demand is low compared to the rest of weekdays, resulting in very high error of 26.63 %. This is may be due to human error in taking the load demand data. However, the rest of the weekdays as well as weekends shows a very good forecasting. Hence, if Tuesday is considered as an outlier, the MAPE will be reduced to 3.20% instead of 6.55%.

Table 4 Forecasted and Actual Electricity Demand for Week 4

WEEK	Forecast	Actual	F-A	ABS F-	ERROR	MAPE
4	3,559.70	3,756.00	-196.3	196.30	5.23	
	5,166.60	5,524.00	-357.4	357.40	6.47	
	5,488.90	5,548.00	-59.1	59.10	1.07	
	5,544.40	5,584.00	-39.6	39.60	0.71	
	5,488.80	5,900.00	-411.2	411.20	6.97	
	4,033.30	4,460.00	-426.7	426.70	9.57	
	3,200.00	3,088.00	112	112.00	3.63	4.80 %

-Thaipusam Holiday

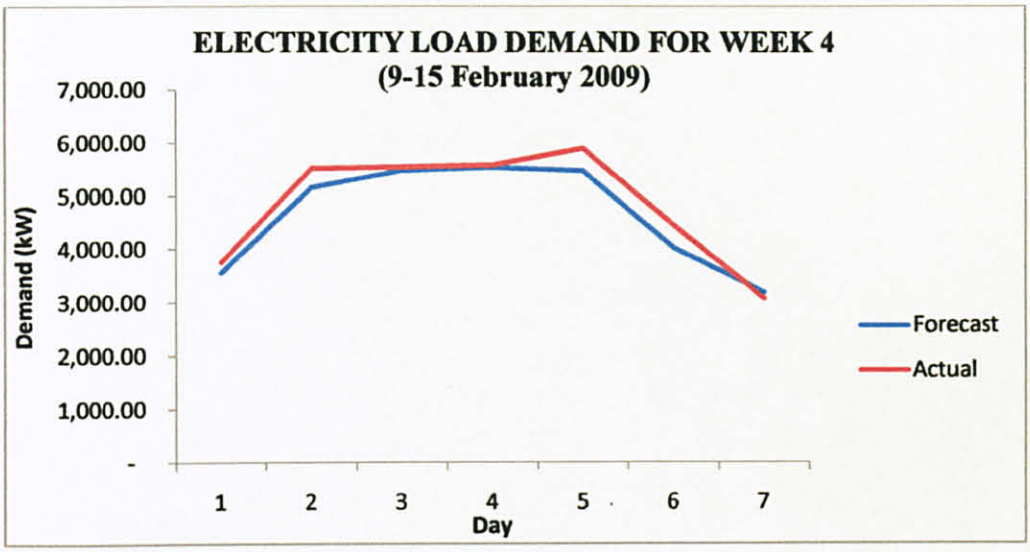

Figure 17 Forecasted and Actual Electricity Demand for Week 4

Since the overall electricity load demand of the fourth week is constant and stable, the MAPE obtained is quite good, which is 4.80%. This shows that the model works well when the load pattern is stable, since the number of IF-THEN rules created is less and it is easier for the model to map out the output.

Table 5 Forecasted and Actual Electricity Demand for Week 5

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
5	5,464.80	5,764.00	-299.2	299.20	5.19	
	5,490.10	5,748.00	-257.9	257.90	4.49	
	5,796.20	5,760.00	36.2	36.20	0.63	
	5,544.40	5,652.00	-107.6	107.60	1.90	
	5,488.80	5,464.00	24.8	24.80	0.45	
	3,727.75	4,004.00	-276.25	276.25	6.90	
	3,600.00	3,628.00	-28	28.00	0.77	2.90 %

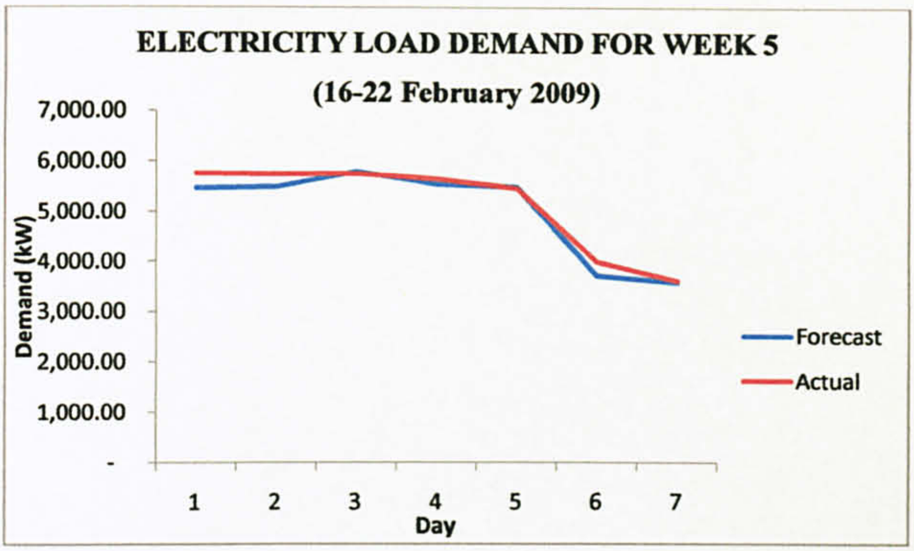

Figure 18 Forecasted and Actual Electricity Demand for Week 5

Table 6 Forecasted and Actual Electricity Demand for Week 6

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
6	5,361.00	5,208.00	153	153.00	2.94	
	5,388.80	5,308.00	80.8	80.80	1.52	
	5,700.00	5,404.00	296	296.00	5.48	
	5,544.40	5,292.00	252.4	252.40	4.77	
	5,488.80	5,172.00	316.8	316.80	6.13	
	3,727.75	3,740.00	-12.25	12.25	0.33	
	3,600.00	3,592.00	8	8.00	0.22	3.05 %

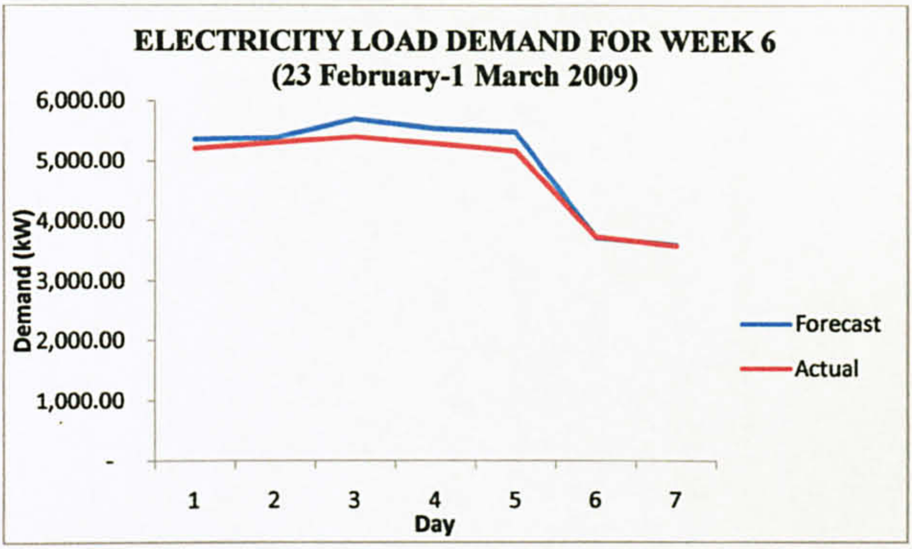

Figure 19 Forecasted and Actual Electricity Demand for Week 6

Table 7 Forecasted and Actual Electricity Demand for Week 7

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
7	5,278.20	5,520.00	-241.8	241.80	4.38	
	5,308.00	5,392.00	-84	84.00	1.56	
	5,623.30	5,804.00	-180.7	180.70	3.11	
	5,544.40	5,496.00	48.4	48.40	0.88	
	5,488.80	5,636.00	-147.2	147.20	2.61	
	4,179.15	3,908.00	271.15	271.15	6.94	
	3,589.65	3,300.00	289.65	289.65	8.78	4.04 %

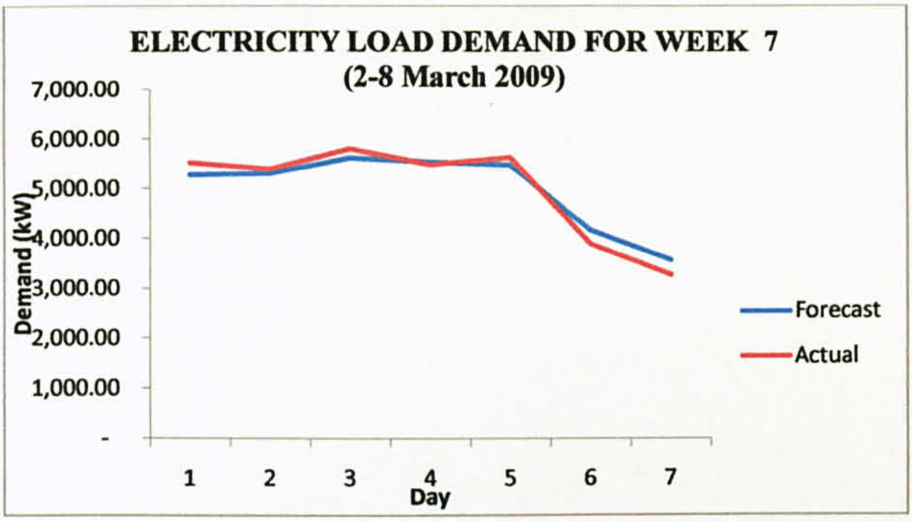

Figure 20 Forecasted and Actual Electricity Demand for Week 7

Table 8 Forecasted and Actual Electricity Demand for Week 8

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
8	2,627.70	2,692.00	-64.3	64.30	2.39	
	5,166.60	5,524.00	-357.4	357.40	6.47	
	5,488.90	5,820.00	-331.1	331.10	5.69	
	5,544.40	5,364.00	180.4	180.40	3.36	
	5,488.80	5,288.00	200.8	200.80	3.80	
	3,750.00	4,052.00	-302	302.00	7.45	
	3,299.95	3,232.00	67.95	67.95	2.10	4.47 %

- Maulidur Rasul Holiday

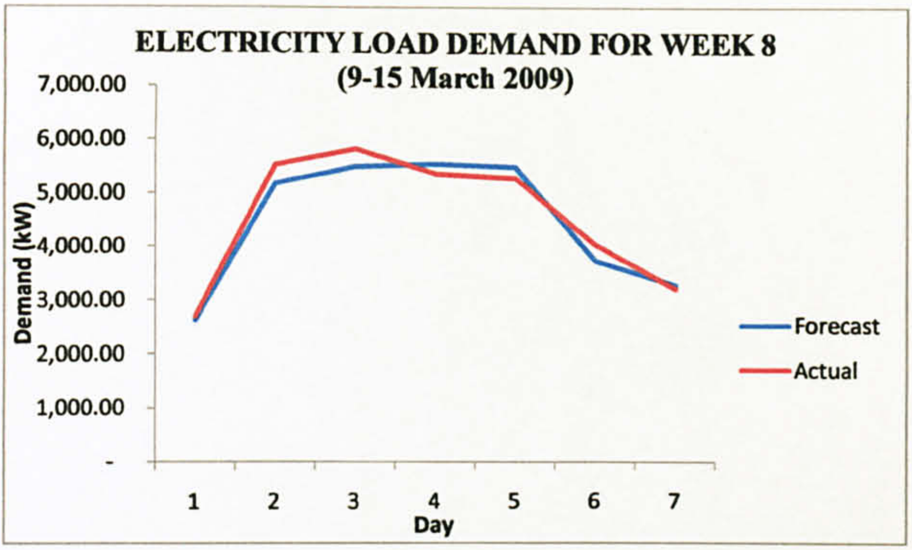

Figure 21 Forecasted and Actual Electricity Demand for Week 8

Table 9 Forecasted and Actual Electricity Demand for Week 9

WEEK	Forecast	Actual	F-A	ABS F-	ERROR	MAPE
9	5,361.00	5,712.00	-351	351.00	6.14	
	5,388.80	5,680.00	-291.2	291.20	5.13	
	5,700.00	5,412.00	288	288.00	5.32	
	5,544.40	5,372.00	172.4	172.40	3.21	
	5,488.80	5,484.00	4.8	4.80	0.09	
	3,033.30	3,220.00	-186.7	186.70	5.80	
	2,500.00	2,420.00	80	80.00	3.31	4.14 %

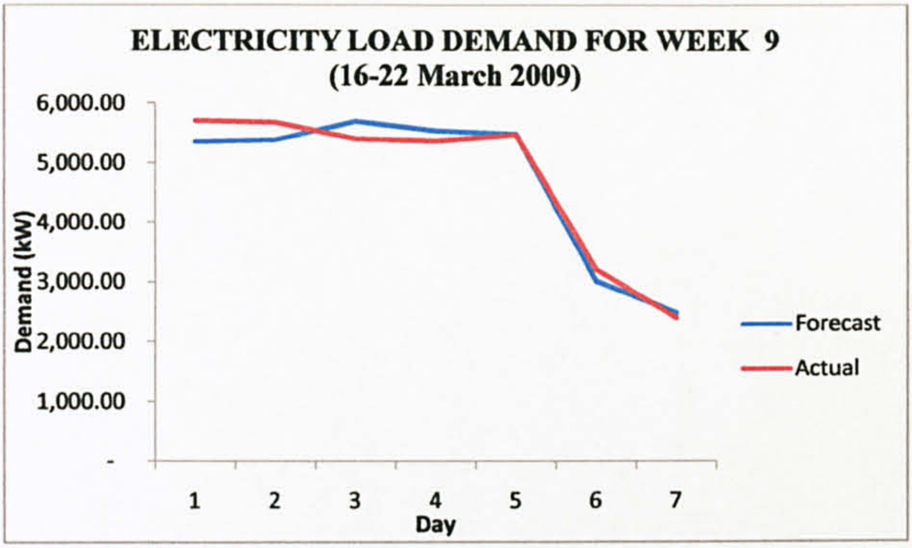

Figure 22 Forecasted and Actual Electricity Demand for Week 9

Table 10 Forecasted and Actual Electricity Demand for Week 10

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
10	4,677.80	4,912.00	-234.2	234.20	4.77	
	4,722.20	4,928.00	-205.8	205.80	4.18	
	4,538.90	4,772.00	-233.1	233.10	4.88	
	4,827.70	4,700.00	127.7	127.70	2.72	
	4,805.50	4,364.00	441.5	441.50	10.12	
	3,200.00	3,104.00	96	96.00	3.09	
	2,733.30	2,996.00	-262.7	262.70	8.77	5.5 %

- Mid-Semester Break

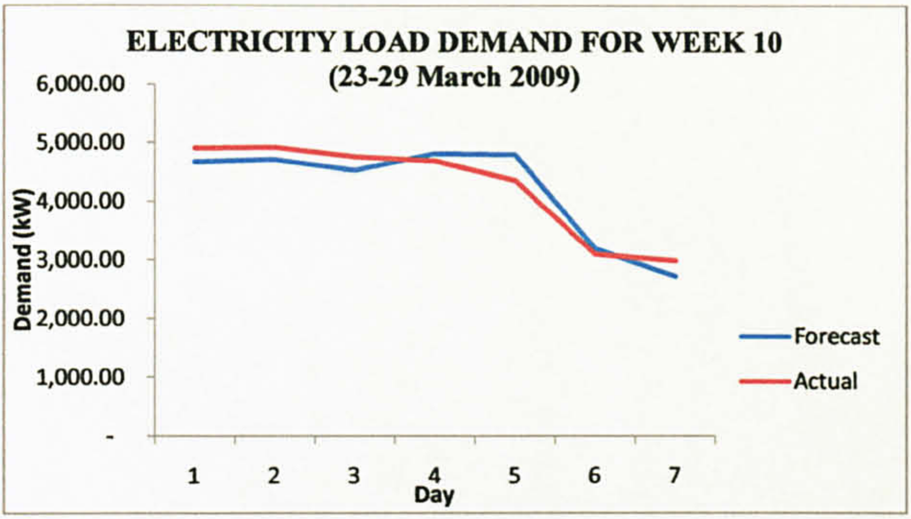

Figure 23 Forecasted and Actual Electricity Demand for Week 10

Week 10 is the mid semester break for UTP. Since it is the holiday season, it is predicted that the number of students will be lesser and the number of facilities that require power supply would be decreasing. So, the value of the electricity load demand is expected to be around 4800kW for weekdays and 3000kW for weekends. The MAPE obtained for the mid semester break week is 5.5%, which is within the allowable range of error.

Table 11 Forecasted and Actual Electricity Demand for Week 11

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
11	5,361.00	5,448.00	-87	87.00	1.60	
	5,388.80	5,524.00	-135.2	135.20	2.45	
	5,700.00	5,448.00	252	252.00	4.63	
	5,544.40	5,412.00	132.4	132.40	2.45	
	5,488.80	5,828.00	-339.2	339.20	5.82	
	4,179.15	4,192.00	-12.85	12.85	0.31	
	3,201.65	3,336.00	-134.35	134.35	4.03	3.04%

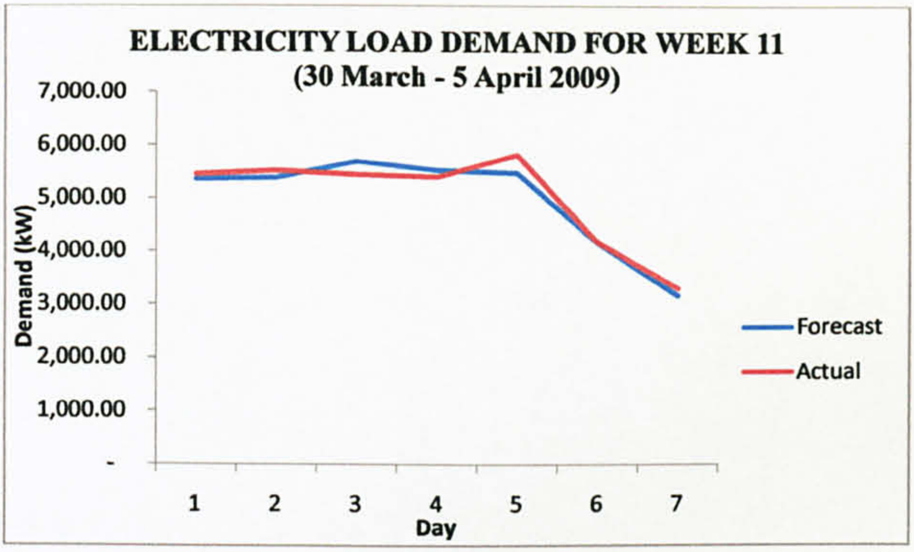

Figure 24 Forecasted and Actual Electricity Demand for Week 11

Table 12 Forecasted and Actual Electricity Demand for Week 12

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
12	5,361.00	5,572.00	-211	211.00	3.79	
	5,388.80	5,848.00	-459.2	459.20	7.85	
	5,700.00	5,824.00	-124	124.00	2.13	
	5,544.40	5,560.00	-15.6	15.60	0.28	
	5,488.80	5,456.00	32.8	32.80	0.60	
	3,727.75	4,068.00	-340.25	340.25	8.36	
	4,200.00	4,232.00	-32	32.00	0.76	3.40%

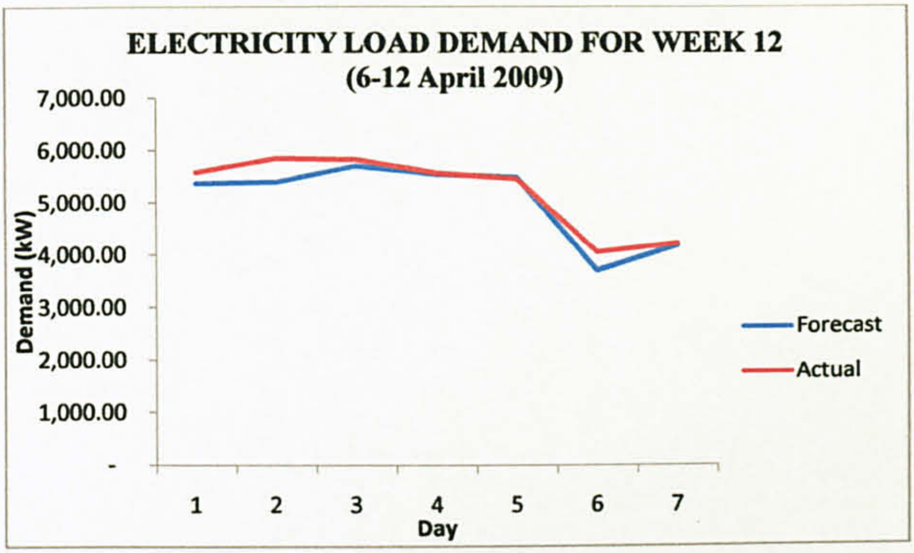

Figure 25 Forecasted and Actual Electricity Demand for Week 12

Table 13 Forecasted and Actual Electricity Demand for Week 13

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
13	5,440.20	5,932.00	-491.8	491.80	8.29	
	5,388.80	6,020.00	-631.2	631.20	10.49	
	5,700.00	5,516.00	184	184.00	3.34	
	5,544.40	5,516.00	28.4	28.40	0.51	
	5,488.80	5,872.00	-383.2	383.20	6.53	
	3,727.75	3,780.00	-52.25	52.25	1.38	
	2,800.00	2,944.00	-144	144.00	4.89	5.06 %

-Sultan Perak's birthday

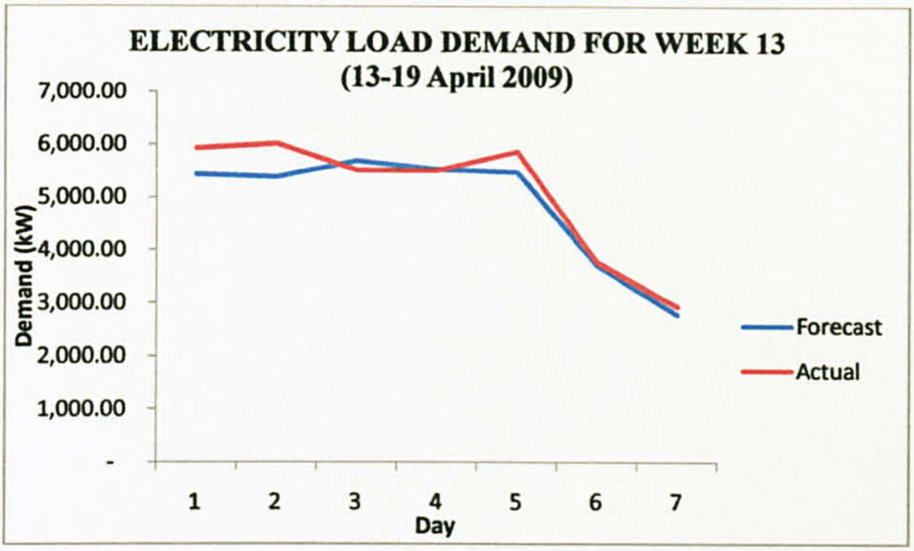

Figure 26 Forecasted and Actual Electricity Demand for Week 13

Table 14 Forecasted and Actual Electricity Demand for Week 14

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
14	3,311.10	3,440.00	-128.9	128.90	3.75	
	5,166.60	5,392.00	-225.4	225.40	4.18	
	5,488.90	5,772.00	-283.1	283.10	4.90	
	5,544.40	6,024.00	-479.6	479.60	7.96	
	5,488.80	5,996.00	-507.2	507.20	8.46	
	3,933.80	3,816.00	117.8	117.80	3.09	
	3,226.95	3,496.00	-269.05	269.05	7.70	5.72 %

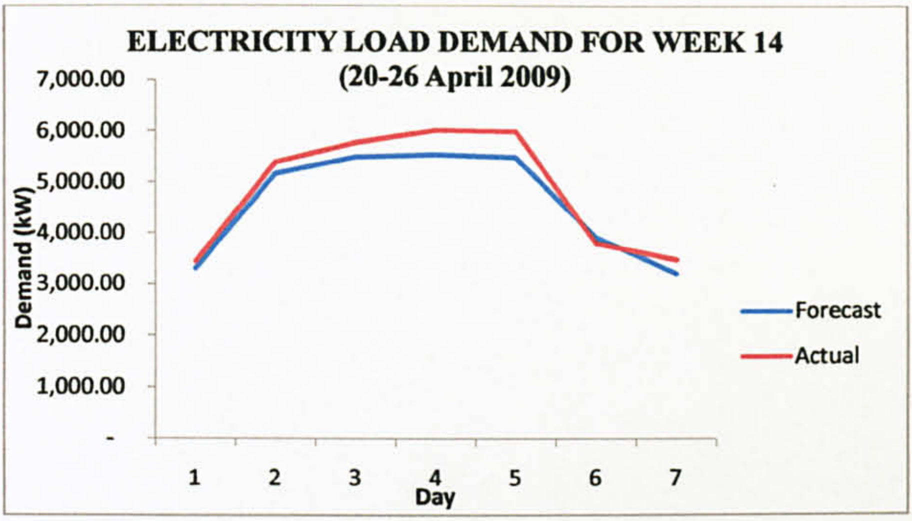

Figure 27 Forecasted and Actual Electricity Demand for Week 14

Table 15 Forecasted and Actual Electricity Demand for Week 15

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
15	5,373.40	5,632.00	-258.6	258.60	4.59	
	5,400.90	5,568.00	-167.1	167.10	3.00	
	7,388.80	7,414.00	-25.2	25.20	0.34	
	5,066.60	5,416.00	-349.4	349.40	6.45	
	3,211.10	3,496.00	-284.9	284.90	8.15	
	3,200.00	3,160.00	40	40.00	1.27	
	2,800.00	2,988.00	-188	188.00	6.29	4.3 %

-Insurance Briefing at Chancellor Hall, Labour Day Holiday

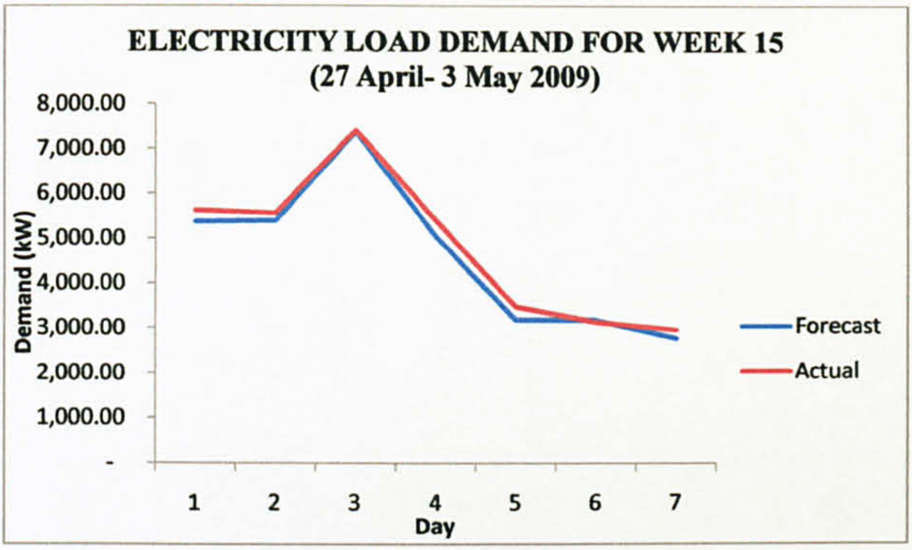

Figure 28 Forecasted and Actual Electricity Demand for Week 15

The MAPE obtained for week 11 to week 15 is ranging from 3.42% to 5.72%. The small value of MAPE shows that the load is forecasted accurately.

Table 16 Forecasted and Actual Electricity Demand for Week 16

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
16	5,664.70	5,204.00	460.7	460.70	8.85	
	5,388.80	5,164.00	224.8	224.80	4.35	
	5,700.00	5,304.00	396	396.00	7.47	
	5,544.40	5,496.00	48.4	48.40	0.88	
	2,527.70	3,272.00	-744.3	744.30	22.75	
	3,033.30	3,200.00	-166.7	166.70	5.21	
	3,200.00	3,528.00	-328	328.00	9.30	8.4 %

-Wesak Day Holiday

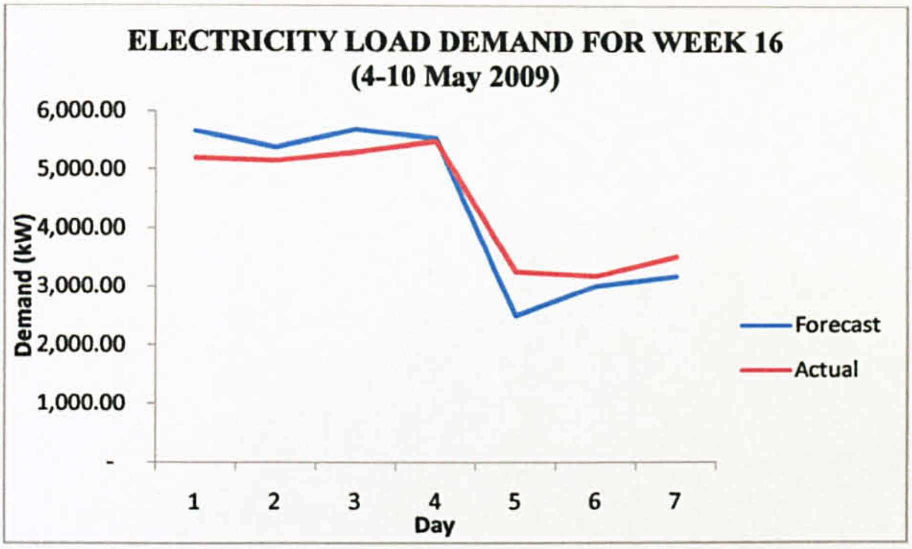

Figure 29 Forecasted and Actual Electricity Demand for Week 16

The MAPE obtained for week 16 is high compared to the previous weeks. This is due to the under forecasting of Friday electricity demand. The 22.75% error is the main factor of obtaining MAPE of 8.4 % of the respective week.

Table 17 Forecasted and Actual Electricity Demand for Week 17

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
17	5,361.00	5,932.00	-571	571.00	9.63	
	5,388.80	5,712.00	-323.2	323.20	5.66	
	5,700.00	6,020.00	-320	320.00	5.32	
	5,544.40	5,608.00	-63.6	63.60	1.13	
	5,488.80	5,748.00	-259.2	259.20	4.51	
	4,134.55	4,388.00	-253.45	253.45	5.78	
	3,522.60	3,552.00	-29.4	29.40	0.83	4.69 %

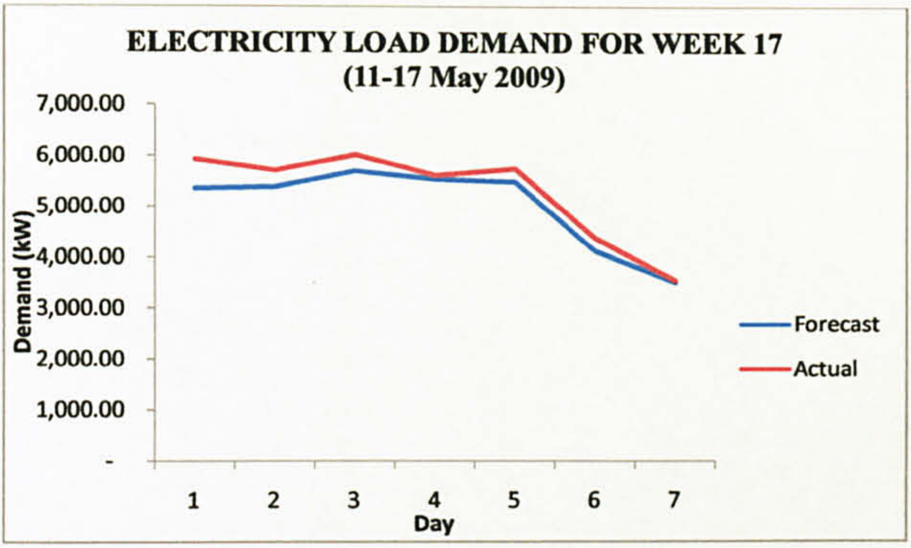

Figure 30 Forecasted and Actual Electricity Demand for Week 17

Table 18 Forecasted and Actual Electricity Demand for Week 18

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
18	5,664.70	5,480.00	184.7	184.70	3.37	
	5,388.80	5,652.00	-263.2	263.20	4.66	
	5,700.00	5,744.00	-44	44.00	0.77	
	5,544.40	5,748.00	-203.6	203.60	3.54	
	5,488.80	5,480.00	8.8	8.80	0.16	
	3,727.75	3,756.00	-28.25	28.25	0.75	
	3,200.00	3,512.00	-312	312.00	8.88	3.16 %

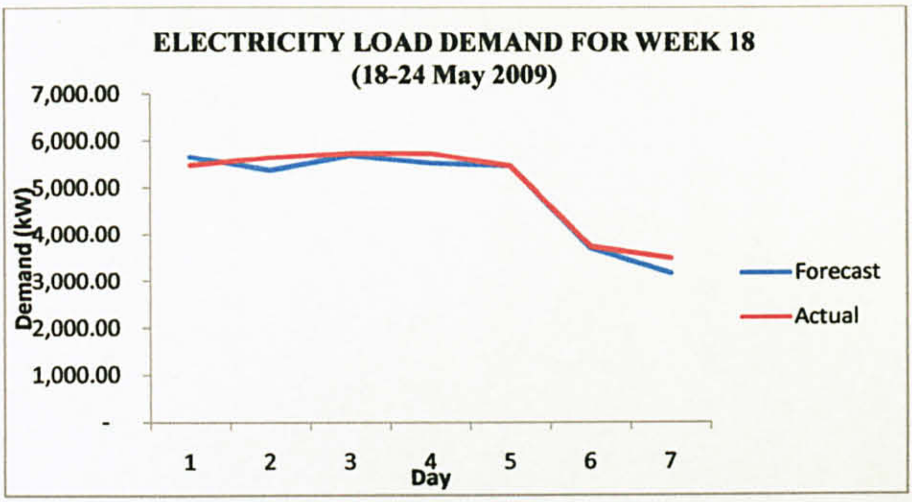

Figure 31 Forecasted and Actual Electricity Demand for Week 18

Table 19 Forecasted and Actual Electricity Demand for Week 19

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
19	5,664.70	5,956.00	-291.3	291.30	4.89	
	5,388.80	5,244.00	144.8	144.80	2.76	
	5,700.00	5,376.00	324	324.00	6.03	
	5,544.40	5,400.00	144.4	144.40	2.67	
	5,488.80	5,192.00	296.8	296.80	5.72	
	3,033.30	3,036.00	-2.7	2.70	0.09	
	2,500.00	2,936.00	-436	436.00	14.85	5.29 %

- Beginning of semester break

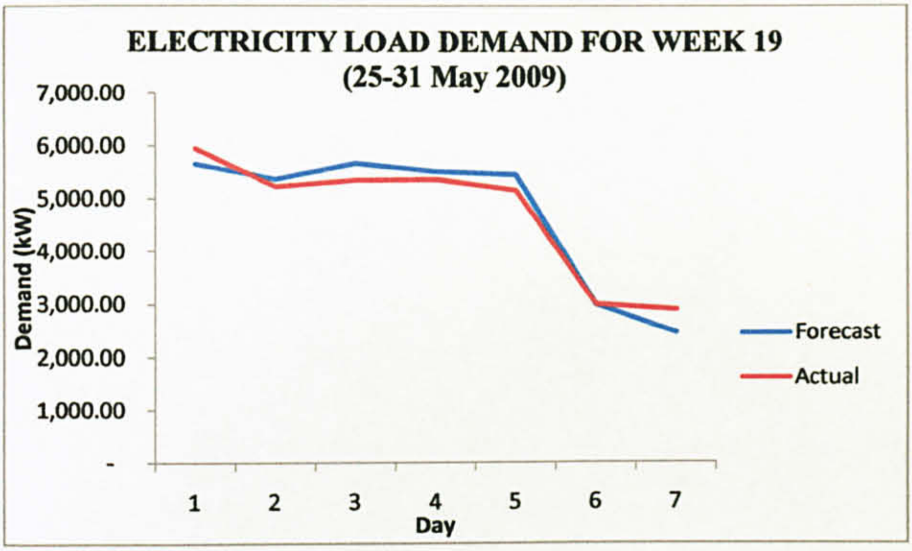

Figure 32 Forecasted and Actual Electricity Demand for Week 19

Table 20 Forecasted and Actual Electricity Demand for Week 20

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
20	4,817.80	5,248.00	-430.2	430.20	8.20	
	4,858.80	4,644.00	214.8	214.80	4.63	
	4,711.40	5,088.00	-376.6	376.60	7.40	
	4,827.70	5,000.00	-172.3	172.30	3.45	
	2,527.70	2,800.00	-272.3	272.30	9.73	
	2,824.95	3,088.00	-263.05	263.05	8.52	
	2,500.05	2,720.00	-219.95	219.95	8.09	7.14 %

-Yang Di-Pertuan Agong's Birthday

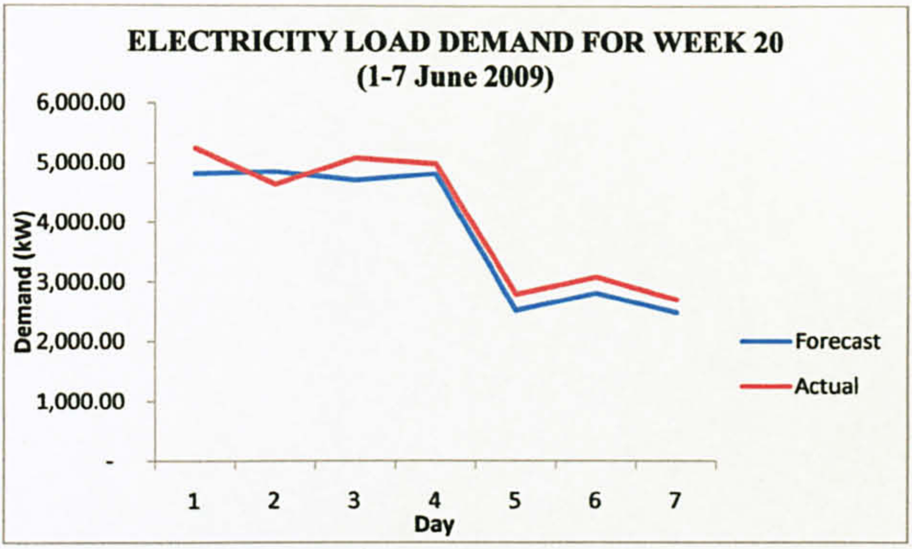

Figure 33 Forecasted and Actual Electricity Demand for Week 20

Table 21 Forecasted and Actual Electricity Demand for Week 21

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
21	5,133.30	5,144.00	-10.7	10.70	0.21	
	5,166.60	5,124.00	42.6	42.60	0.83	
	5,488.90	5,312.00	176.9	176.90	3.33	
	5,544.40	4,776.00	768.4	768.40	16.09	
	5,488.80	4,780.00	708.8	708.80	14.83	
	2,825.05	2,772.00	53.05	53.05	1.91	
	2,733.30	2,772.00	-38.7	38.70	1.40	5.51 %

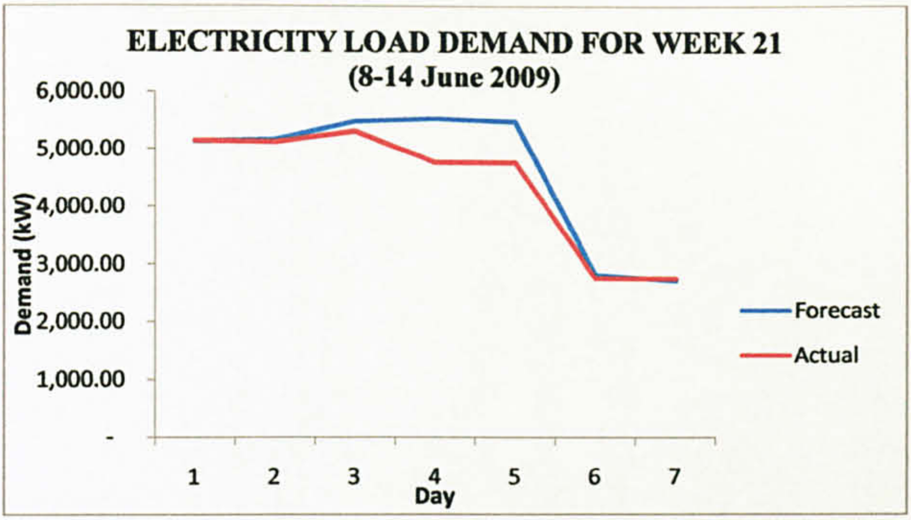

Figure 34 Forecasted and Actual Electricity Demand for Week 21

The MAPE obtained for week 17 to week 21 is ranging from 3.16% to 7.14%. The small value of MAPE shows that the model is forecasting the electricity load demand with a high accuracy.

Table 22 Forecasted and Actual Electricity Demand for Week 22

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
22	4,222.20	4,488.00	-265.8	265.80	5.92	
	4,277.80	4,992.00	-714.2	714.20	14.31	
	4,644.40	4,796.00	-151.6	151.60	3.16	
	4,588.90	5,942.00	-1353.1	1,353.10	22.77	
	4,577.80	4,646.00	-68.2	68.20	1.47	
	2,824.95	2,964.00	-139.05	139.05	4.69	
	2,733.30	2,308.00	425.3	425.30	18.43	10.11 %

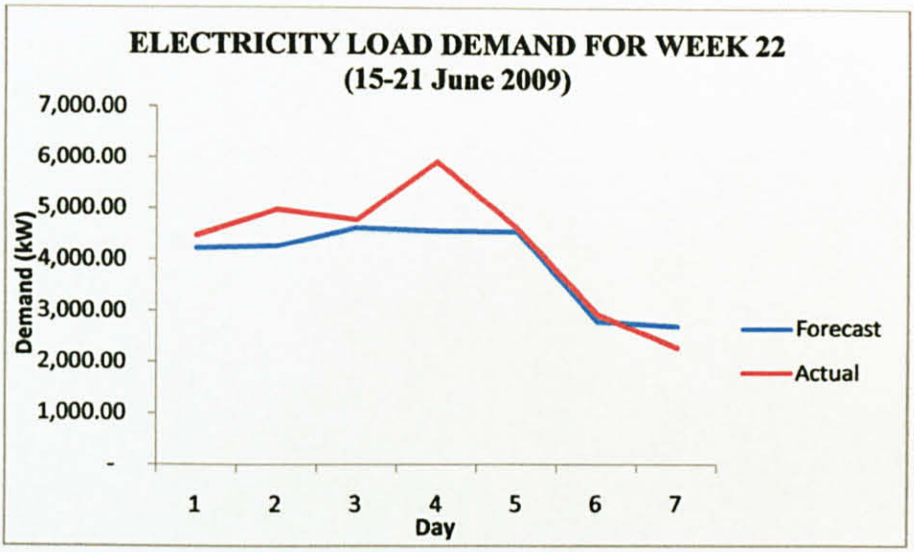

Figure 35 Forecasted and Actual Electricity Demand for Week 22

Table 23 Forecasted and Actual Electricity Demand for Week 23

WEEK	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
23	4,887.40	4,680.00	207.4	207.40	4.43	
	4,926.70	4,568.00	358.7	358.70	7.85	
	4,822.90	4,936.00	-113.1	113.10	2.29	
	4,827.70	4,834.00	-6.3	6.30	0.13	
	4,805.50	4,576.00	229.5	229.50	5.02	
	2,824.95	2,600.00	224.95	224.95	8.65	
	2,200.00	2,296.00	-96	96.00	4.18	6.37 %

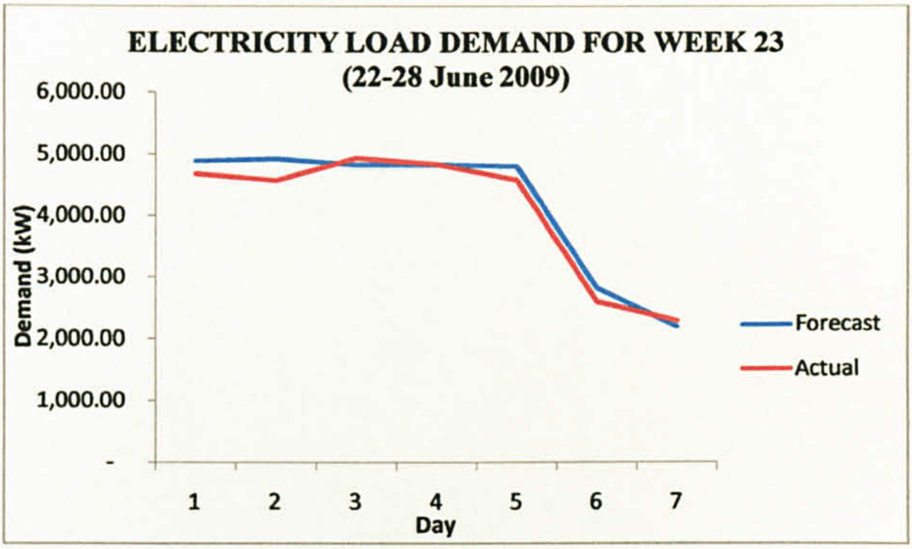

Figure 36 Forecasted and Actual Electricity Demand for Week 23

Table 24 Forecasted and Actual Electricity Demand for Week 24

	Forecast	Actual	F-A	ABS F-A	ERROR	MAPE
24	4,450.00	4,468.00	-18	18.00	0.40	
	4,500.00	4,144.00	356	356.00	8.59	
	4,566.30	4,072.00	494.3	494.30	12.14	
	4,765.60	4,116.00	649.6	649.60	15.78	
	4,746.20	4,440.00	306.2	306.20	6.90	
	2,824.95	3,348.00	-523.05	523.05	15.62	
	2,733.30	2,516.00	217.30	217.30	8.64	9.72%

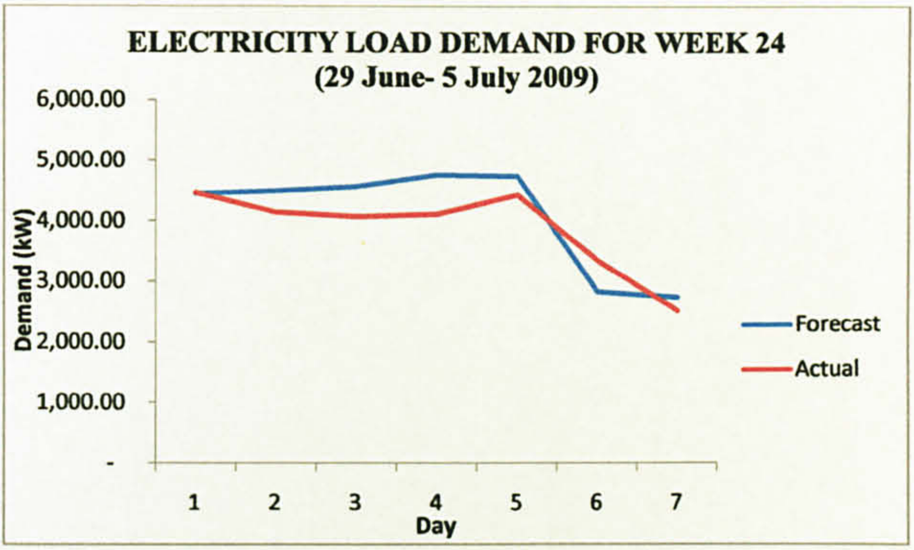

Figure 37 Forecasted and Actual Electricity Demand for Week 24

The MAPE obtained for the semester break is slightly higher compared to the semester on. This is due to the random usage of some of the facilities in Chancellor Complex for certain events such as trainings and seminar. Thus, the load demand for a certain week is unstable, resulting in higher MAPE.

The MAPE is computed in terms of weekly MAPE. The MAPE calculation when semester on and semester off can be calculated as follows:

$$\text{MAPE}_{(\text{overall})} = \frac{\sum \text{MAPE}_{(sem\ on+sem\ off)}}{\text{No of week}_{(sem\ on+sem\ o)}} \times 100\% \qquad 4.1$$

$$\text{MAPE}_{(\text{sem on})} = \frac{\sum \text{MAPE}_{(sem\ on)}}{\text{No of week}_{(sem\ on)}} \times 100\% \qquad 4.2$$

$$\text{MAPE}_{(\text{sem off})} = \frac{\sum \text{MAPE}_{(sem\ off)}}{\text{No of week}_{(sem\ off)}} \times 100\% \qquad 4.3$$

The overall results are summarised as follows:

Table 25 Summarised Results

Overall MAPE	5.15%
Semester on MAPE	4.49%
Semester off MAPE	7.40%

The results summarised in the Table 4.25 shows that the model works for forecasting the electricity load demand both during the semester on and semester off. However, it can be seen that the MAPE obtained for the semester on is significantly better than during semester off. This is due to the unstable load demand during the semester off. However, since the overall MAPE for the semester off does not exceed 8%, the model is still considered applicable for the semester January 2009 electricity load forecasting. The model can also be used for medium term and long term load forecasting, since the overall MAPE of the January 2009 semester (5 months) is 5.15%. The graph below shows the actual and forecasted electricity load demand for January 2009 semester.

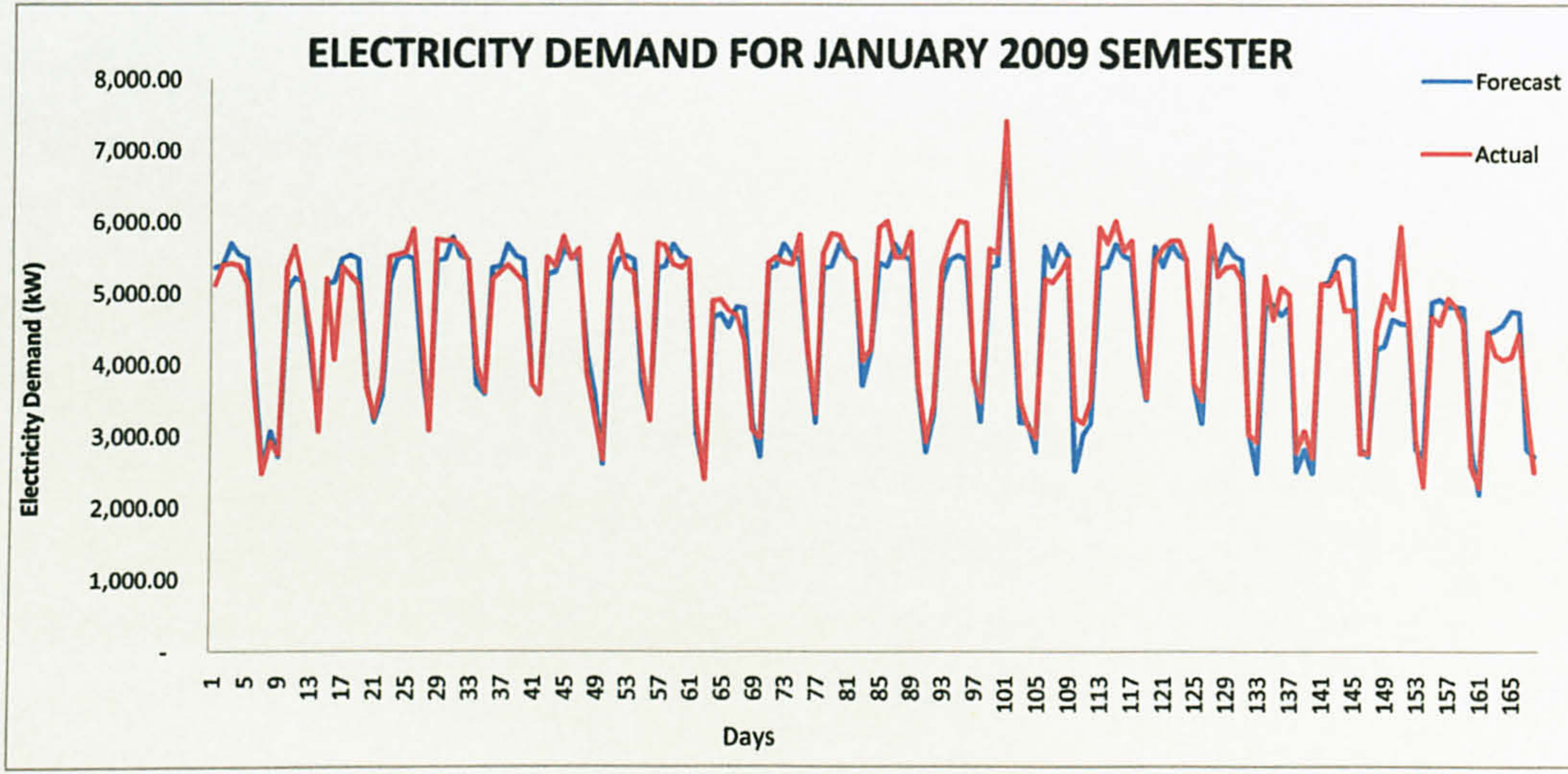

Figure 38 Electricity Load Demand for January 2009 Semester

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the studies, there are a few conclusions can be made. Firstly, more factors affecting the future load demand should be considered in forecasting the future load in order to have more accurate results. Since Fuzzy Logic can compute both quantitative and qualitative factors, it is the best method to be used to forecast the UTP future load demand. The optimum MAPE of less than 8% obtained for semester on, semester off as well as for the whole semester proved that the method used is suitable to be employed by GDC for UTP load forecasting.

Other than that, the latest data is more suitable to be used to forecast the future demand in UTP. This is because the existence of loads to the latest units in the campus such as the seminar rooms in the Undercroft has been considered. During semester off, the academic activities are slowed down, which in turn reduced the electricity load demand. However, the usage of some units in the chancellor complex like the lecture theatres and tutorial rooms for training and seminars purposes held during particular days within the semester breaks would in a way increase the instability of the electricity load demand. Based on result obtained, it was found that such events caused a MAPE of 7.40% during the semester off.

Maintaining a balanced load distribution to all sections in UTP throughout the year is important to avoid power shortage, overload, and also power disruption. Many times, incidence like this would cause lost in time and generation cost. Therefore, it is important to be able to forecast the future load in UTP. This project has encapsulated major activities and events that were held in UTP for the entire semester. Based on the project done alongside the cross reference with data obtained from GDC, it is proven that by forecasting future loads, we are able to prepare UTP with enough loads when it is needed. The forecasting of future load in UTP allows for pre-planned scheduling and maintenance for the plant as well as to reduce generation cost when the total load needed for a specific time is known in advance.

5.2 Recommendation

It is recommended that GDC employs the electricity forecasting using Fuzzy Logic to be applied in its plant since it is able to obtain much accurate results for future load demand. The findings of the project should be utilized by the GDC for planning and scheduling maintenance of the plant. Besides that, user is also encouraged to have a thorough study on the behaviour of UTP's future load demand especially when Pocket A and Pocket B has been completed. This is essential for future planning of the power generation of GDC. A model that is capable of forecasting the load demand in the medium and long term is proposed to be built to simulate possible courses of action to be taken before the occurrence of electricity load shortage, failure or disruption supplied to UTP. This way, the generation cost for particular time would be able to be predicted accurately.

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APPENDICES

APPENDIX A

Membership Functions of the model used

INPUT VARIABLES

DAY TYPE

Public Holiday	1
Normal Day	2
Special Occasion	3

SEMESTER TYPE

Semester Break	1
Semester On	2

PREVIOUS WEEKDAY AVERAGE LOAD

Very-Very Low	3000.00-3622.20 kW
Very Low	3622.20- 3931.85 kW
Low	3931.85-4245.45 kW
Medium	4245.45-4559.45 kW
Medium-High	4559.45-4868.15 kW
High	4868.15-5177.30 kW
Very High	5177.30-5409.25 kW
Very-Very High	5409.25-5800.99 kW

AVERAGE MAXIMUM TEMPERATURE FOR NEXT WEEKDAYS [19]

Rainy	30.00-31.67°C
Cool	31.67-32.50°C
Average	32.50-33.33°C
Warm	33.33-34.18°C
Hot	34.18-35.00°C

MAXIMUM TEMPERATURE FOR NEXT SATURDAY [19]

Rainy	23-27°C
Cool	27-29°C
Average	29-31°C
Warm	31-33°C
Hot	33-35°C

PREVIOUS SATURDAY LOAD

Very Low	2000-2766.65 kW
Low	2766.5-3150 kW
Medium	3150-3530.15 kW
High	3530.15-3929.35kW
Very High	3929.35-4300 kW

MAXIMUM TEMPERATURE FOR NEXT SUNDAY [19]

Rainy	27.00-29.67°C
Cool	29.67-31.00°C
Average	31.00-32.33°C
Warm	32.33-33.70°C
Hot	33.70-35.00°C

PREVIOUS SUNDAY AVERGE LOAD

Very Low	2000-2800 kW
Low	2800-3140 kW
Medium	3140-3600 kW
High	3600-4000 kW
Very High	4000-4400 kW

OUTPUT VARIABLES

FORECASTED LOAD DEMAND- MONDAY

Very-Very Low	2400.0-3311.1 kW
Very Low	3311.1-3768.2 kW
Low	3768.2-4224.3 kW
Medium	4224.3-4675.2 kW
Medium-High	4675.2-5131.8 kW
High	5131.8-5587.9 kW
Very High	5587.9-6043.9 kW
Very-Very High	6043.9-6500.0 kW

FORECASTED LOAD DEMAND -TUESDAY

Very-Very Low	2500.0-3388.9 kW
Very Low	3388.9-3843.4 kW
Low	3843.4-4275.3 kW
Medium	4275.3-4720.2 kW
Medium-High	4720.2-5169.7 kW
High	5169.7-5614.6 kW
Very High	5614.6-6058.3 kW
Very-Very High	6058.3-6500.0 kW

FORECASTED LOAD DEMAND -WEDNESDAY

Very-Very Low	3800.0-4644.4 kW
Very Low	4644.4-5063.8 kW
Low	5063.8-5490.8 kW
Medium	5490.8-5909.2 kW
Medium-High	5909.2-6331.9 kW
High	6331.9-6750.3 kW
Very High	6750.3-7181.6 kW
Very-Very High	7181.6-7600.0 kW

FORECASTED LOAD DEMAND -THURSDAY

Very-Very Low	2200.0-3155.5 kW
Very Low	3155.5-3634.9 kW
Low	3634.9-4113.3 kW
Medium	4113.3-4586.7 kW
Medium-High	4586.7-5065.1 kW
High	5065.1-5548.2 kW
Very High	5548.2-6031.3 kW
Very-Very High	6031.3-6500.0 kW

FORECASTED LOAD DEMAND -FRIDAY

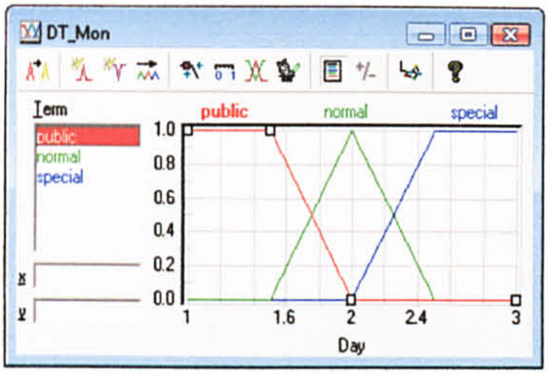
Very-Very Low	2300.0-3211.1 kW
Very Low	3211.1-3668.2 kW
Low	3668.2-4124.3 kW
Medium	4124.3-4575.7 kW
Medium-High	4575.7-5031.8 kW
High	5031.8-5492.5 kW
Very High	5492.5-5943.5 kW
Very-Very High	5943.5-6400.0 kW

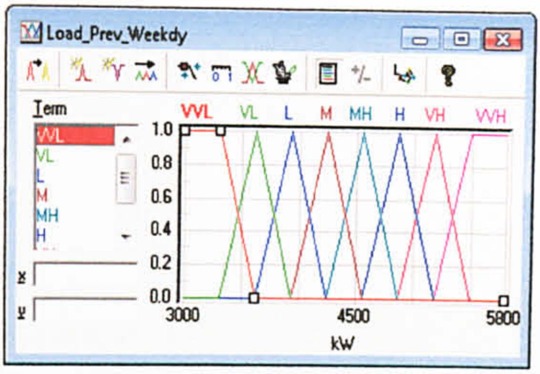
FORECASTED LOAD DEMAND -SATURDAY

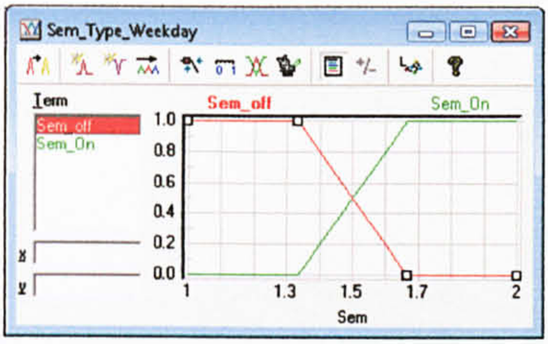
Very Low	22000.0-3033.3 kW
Low	3033.3-3450.0 kW
Medium	3450.0-3868.0 kW
High	3868.8-4297.1 kW
Very High	4297.1-4700.0 kW

FORECASTED LOAD DEMAND -SUNDAY

Very Low	2000-2800 kW
Low	2800-3140 kW
Medium	3140-3600 kW
High	3600-4000 kW
Very High	4000-4400 kW


DT_Mon
Term
public
normal
special
1.0
0.8
0.6
0.4
0.2
0.0
1
1.6
2
2.4
3
Day


Load_Prev_Weekdy
Term
VVL
VL
L
M
MH
H
VH
VVH
1.0
0.8
0.6
0.4
0.2
0.0
3000
4500
5800
kW


Sem_Type_Weekday
Term
Sem_off
Sem_On
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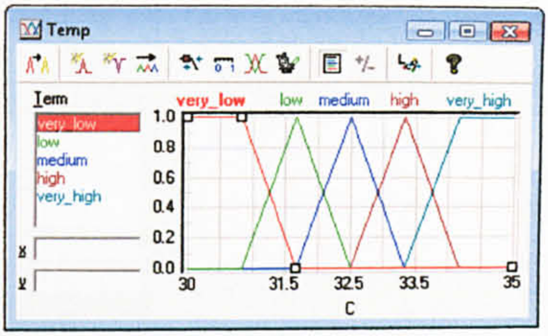
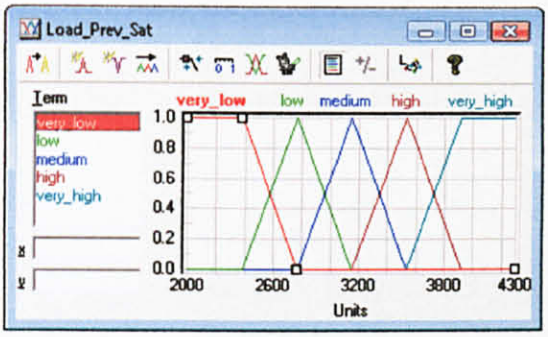
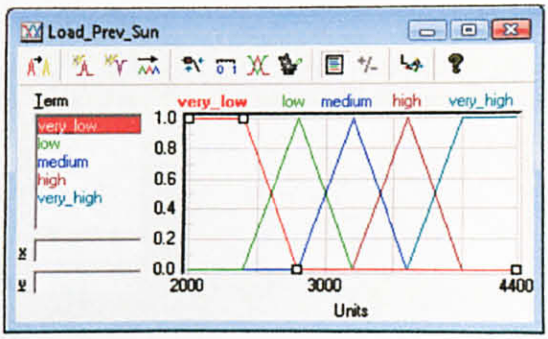
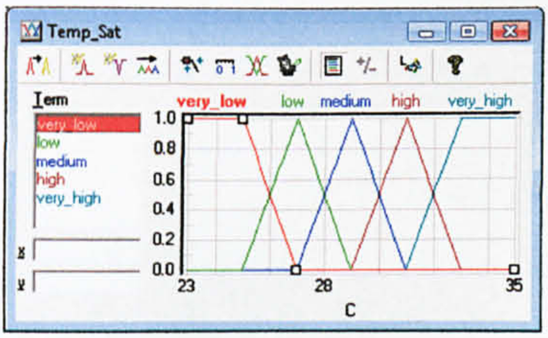
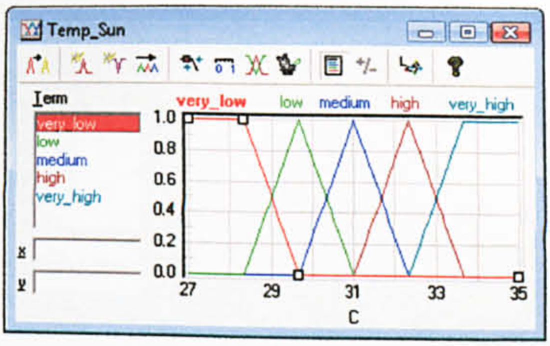
0.8
0.6
0.4
0.2
0.0
1
1.3
1.5
1.7
2
Sem

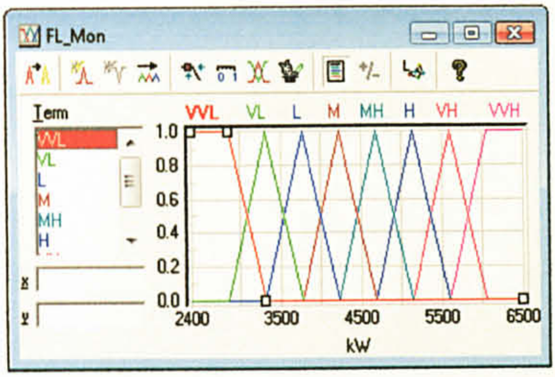

Temp
Term
very_low
low
medium
high
very_high
1.0
0.8
0.6
0.4
0.2
0.0
30
31.5
32.5
33.5
35
C

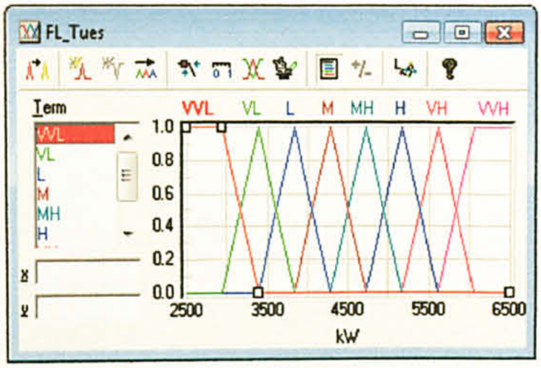

Load_Prev_Sat
Term
very_low
low
medium
high
very_high
1.0
0.8
0.6
0.4
0.2
0.0
2000
2600
3200
3800
4300
Units

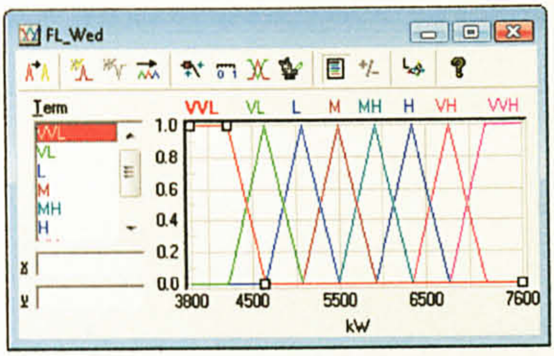

Load_Prev_Sun
Term
very_low
low
medium
high
very_high
1.0
0.8
0.6
0.4
0.2
0.0
2000
3000
4400
Units

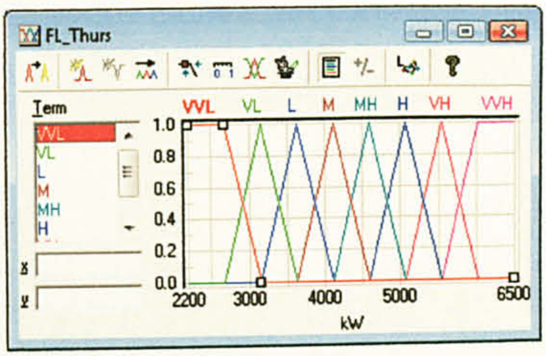

Temp_Sat
Term
very_low
low
medium
high
very_high
1.0
0.8
0.6
0.4
0.2
0.0
23
28
35
C

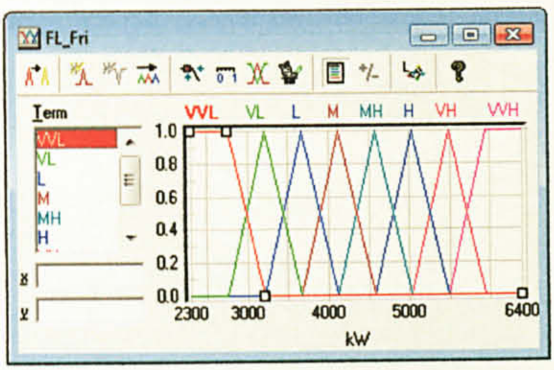

Temp_Sun
Term
very_low
low
medium
high
very_high
1.0
0.8
0.6
0.4
0.2
0.0
27
29
31
33
35
C

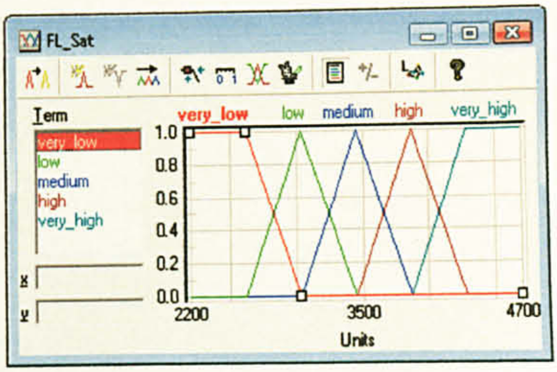

FL_Mon
Term
VVL VL L M MH H VH VVH
1.0 0.8 0.6 0.4 0.2 0.0
2400 3500 4500 5500 6500
kW

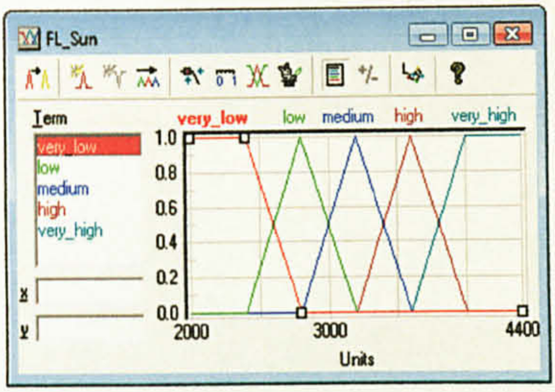

FL_Tues
Term
VVL VL L M MH H VH VVH
1.0 0.8 0.6 0.4 0.2 0.0
2500 3500 4500 5500 6500
kW


FL_Wed
Term
VVL VL L M MH H VH VVH
1.0 0.8 0.6 0.4 0.2 0.0
3800 4500 5500 6500 7600
kW


FL_Thurs
Term
VVL VL L M MH H VH VVH
1.0 0.8 0.6 0.4 0.2 0.0
2200 3000 4000 5000 6500
kW


FL_Fri
Term
VVL VL L M MH H VH VVH
1.0 0.8 0.6 0.4 0.2 0.0
2300 3000 4000 5000 6400
kW

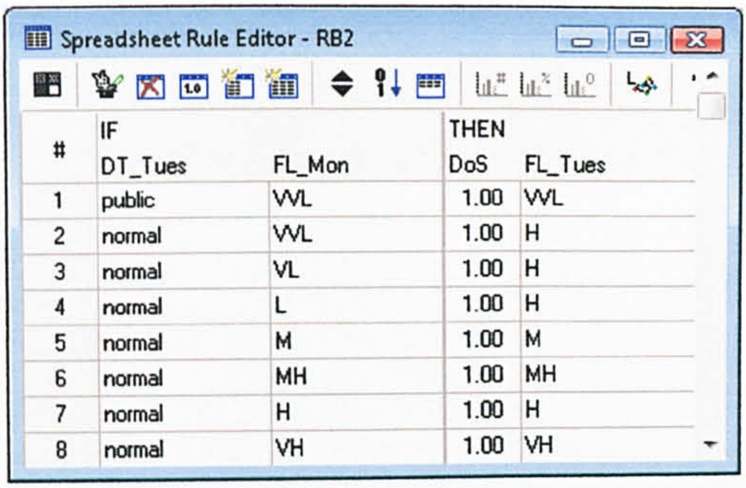

FL_Sat
Term
very_low low medium high very_high
1.0 0.8 0.6 0.4 0.2 0.0
2200 3500 4700
Units


FL_Sun
Term
very_low low medium high very_high
1.0 0.8 0.6 0.4 0.2 0.0
2000 3000 4400
Units

APPENDIX B: THE IF –THEN RULES

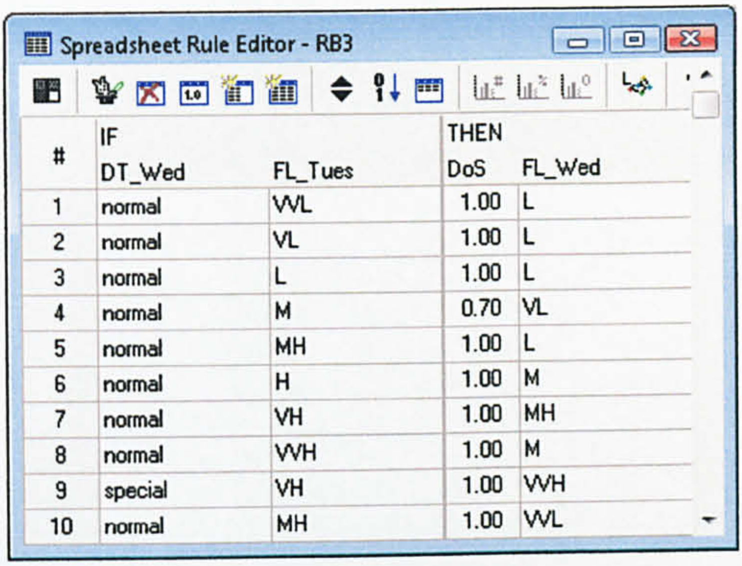
Spreadsheet Rule Editor - RB1

#	IF DT_Mon	Load_Prev_Weel	Sem_Type_Weel	Temp	THEN DoS	FL_Mon
2	public	H	Sem_On	very_low	1.00	VL
3	public	H	Sem_On	low	1.00	VL
4	public	H	Sem_On	medium	1.00	L
5	public	H	Sem_On	high	1.00	L
6	public	H	Sem_On	very_high	1.00	L
7	public	VH	Sem_On	very_low	1.00	VVL
8	public	VH	Sem_On	low	1.00	VVL
9	public	VH	Sem_On	medium	1.00	VL
10	public	VH	Sem_On	high	1.00	VL
11	public	VH	Sem_On	very_high	1.00	VL
12	public	VVH	Sem_On	very_low	1.00	VVL
13	public	VVH	Sem_On	low	1.00	VVL
14	public	VVH	Sem_On	medium	1.00	VL
15	public	VVH	Sem_On	high	1.00	VL
16	public	VVH	Sem_On	very_high	1.00	VL
17	normal	VVL	Sem_off	low	1.00	M
18	normal	M	Sem_off	very_low	1.00	MH
19	normal	VVH	Sem_off	medium	1.00	MH
20	normal	VH	Sem_off	medium	1.00	H
21	normal	MH	Sem_off	very_high	1.00	H
22	normal	VH	Sem_off	high	1.00	M
23	normal	H	Sem_off	medium	1.00	MH
24	normal	MH	Sem_off	medium	1.00	M
25	normal	H	Sem_On	medium	1.00	H
26	normal	M	Sem_On	low	1.00	H
27	normal	VVH	Sem_On	low	1.00	H
28	normal	VH	Sem_On	low	1.00	H
29	normal	H	Sem_On	medium	1.00	VH
30	normal	MH	Sem_On	medium	1.00	H
31	normal	VVH	Sem On	low	1.00	VH
32	normal	VH	Sem_On	very_high	1.00	VH
33	normal	VVH	Sem_On	very_high	1.00	H
34	normal	MH	Sem_On	very_high	1.00	VH
35	normal	VVH	Sem_On	medium	1.00	H
36	normal	VVH	Sem_On	medium	1.00	VH
37	normal	VVH	Sem_On	medium	1.00	VVH



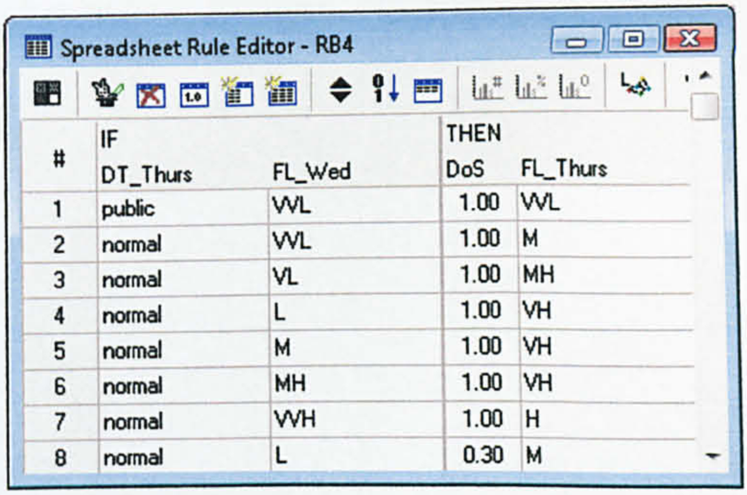
Spreadsheet Rule Editor - RB2

#	IF DT_Tues	IF FL_Mon	THEN DoS	THEN FL_Tues
1	public	VVL	1.00	VVL
2	normal	VVL	1.00	H
3	normal	VL	1.00	H
4	normal	L	1.00	H
5	normal	M	1.00	M
6	normal	MH	1.00	MH
7	normal	H	1.00	H
8	normal	VH	1.00	VH



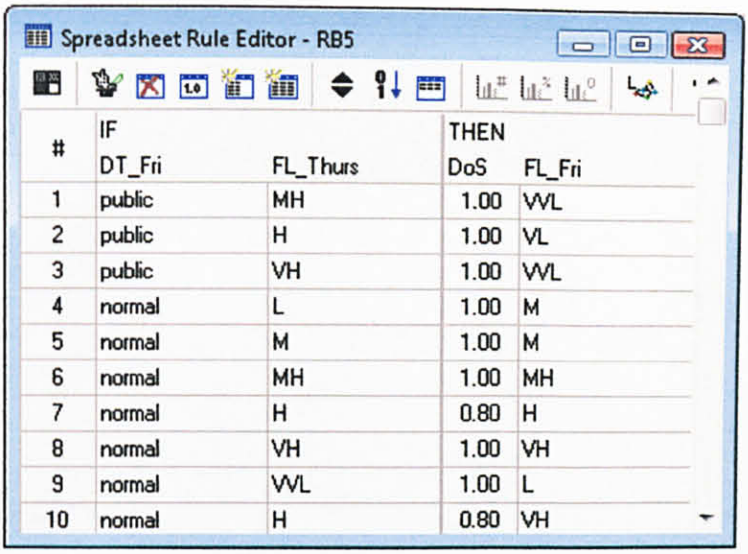
Spreadsheet Rule Editor - RB3

#	IF DT_Wed	IF FL_Tues	THEN DoS	THEN FL_Wed
1	normal	VVL	1.00	L
2	normal	VL	1.00	L
3	normal	L	1.00	L
4	normal	M	0.70	VL
5	normal	MH	1.00	L
6	normal	H	1.00	M
7	normal	VH	1.00	MH
8	normal	VVH	1.00	M
9	special	VH	1.00	VVH
10	normal	MH	1.00	VVL



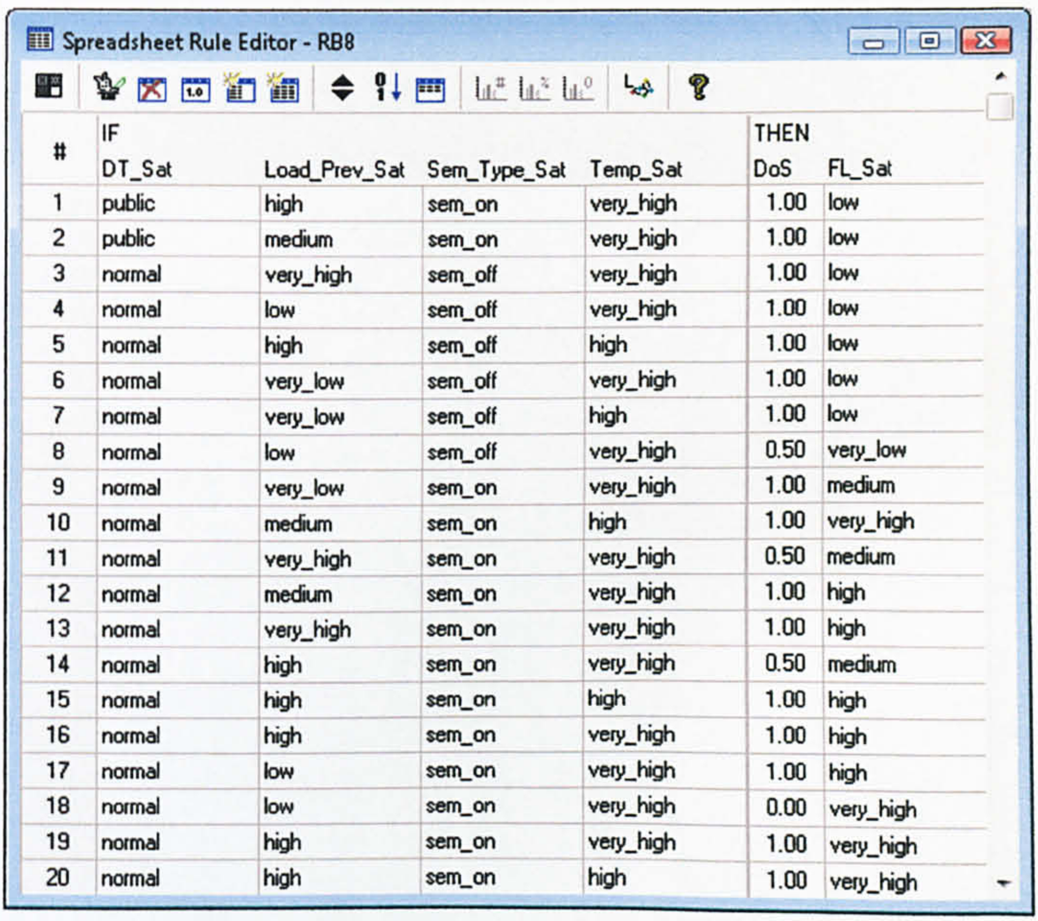
Spreadsheet Rule Editor - RB4

#	IF DT_Thurs	IF FL_Wed	THEN DoS	THEN FL_Thurs
1	public	VVL	1.00	VVL
2	normal	VVL	1.00	M
3	normal	VL	1.00	MH
4	normal	L	1.00	VH
5	normal	M	1.00	VH
6	normal	MH	1.00	VH
7	normal	VVH	1.00	H
8	normal	L	0.30	M



Spreadsheet Rule Editor - RB5

#	IF DT_Fri	FL_Thurs	THEN DoS	FL_Fri
1	public	MH	1.00	VVL
2	public	H	1.00	VL
3	public	VH	1.00	VVL
4	normal	L	1.00	M
5	normal	M	1.00	M
6	normal	MH	1.00	MH
7	normal	H	0.80	H
8	normal	VH	1.00	VH
9	normal	VVL	1.00	L
10	normal	H	0.80	VH



Spreadsheet Rule Editor - RB8

#	IF DT_Sat	Load_Prev_Sat	Sem_Type_Sat	Temp_Sat	THEN DoS	FL_Sat
1	public	high	sem_on	very_high	1.00	low
2	public	medium	sem_on	very_high	1.00	low
3	normal	very_high	sem_off	very_high	1.00	low
4	normal	low	sem_off	very_high	1.00	low
5	normal	high	sem_off	high	1.00	low
6	normal	very_low	sem_off	very_high	1.00	low
7	normal	very_low	sem_off	high	1.00	low
8	normal	low	sem_off	very_high	0.50	very_low
9	normal	very_low	sem_on	very_high	1.00	medium
10	normal	medium	sem_on	high	1.00	very_high
11	normal	very_high	sem_on	very_high	0.50	medium
12	normal	medium	sem_on	very_high	1.00	high
13	normal	very_high	sem_on	very_high	1.00	high
14	normal	high	sem_on	very_high	0.50	medium
15	normal	high	sem_on	high	1.00	high
16	normal	high	sem_on	very_high	1.00	high
17	normal	low	sem_on	very_high	1.00	high
18	normal	low	sem_on	very_high	0.00	very_high
19	normal	high	sem_on	very_high	1.00	very_high
20	normal	high	sem_on	high	1.00	very_high

Spreadsheet Rule Editor - RB7

#	IF				THEN	
	DT_Sun	Load_Prev_Sun	Sem_type_Sun	Temp_Sun	DoS	FL_Sun
1	public	medium	sem_on	very_low	1.00	very_low
2	public	low	sem_on	high	1.00	medium
3	public	very_high	sem_on	low	1.00	low
4	public	medium	sem_on	low	1.00	low
5	public	low	sem_on	very_high	1.00	medium
6	public	medium	sem_on	very_low	1.00	low
7	normal	medium	sem_off	high	1.00	very_low
8	normal	very_low	sem_off	very_high	1.00	low
9	normal	medium	sem_off	very_high	1.00	low
10	normal	very_low	sem_off	very_high	1.00	very_low
11	normal	low	sem_off	very_high	1.00	very_low
12	normal	very_low	sem_off	high	1.00	very_low
13	normal	very_low	sem_off	medium	1.00	very_low
14	normal	very_low	sem_off	high	1.00	medium
15	normal	very_low	sem_off	high	1.00	low
16	normal	medium	sem_off	high	1.00	low
17	normal	very_low	sem_on	medium	1.00	medium
18	normal	medium	sem_on	very_high	1.00	low
19	normal	low	sem_on	low	1.00	high
20	normal	high	sem_on	high	1.00	high
21	normal	medium	sem_on	high	1.00	medium
22	normal	low	sem_on	very_high	1.00	medium
23	normal	medium	sem_on	very_high	1.00	very_high
24	normal	low	sem_on	very_high	1.00	high
25	normal	medium	sem_on	very_high	1.00	medium
26	normal	medium	sem_on	very_high	1.00	very_low
27	normal	medium	sem_on	very_high	1.00	high
28	special	medium	sem_on	very_high	1.00	very_high

APPENDIX C

ACADEMIC CALENDAR 2009

JANUARY 2009 SEMESTER (UNDERGRADUATE)

PARTICULARS	NO. OF WEEKS	DATE	
		START	ENDS
Registration and Orientation of New Students	1	10 Jan 2009	18 Jan 2009
Registration of Existing Students	1 day	18 Jan 2009	
Lecture	9	19 Jan 2009	20 March 2009
Mid-Semester Break	1	21 March 2009	29 March 2009
Lecture	5	30 March 2009	1 May 2009
Study Week	1	2 May 2009	10 May 2009
Examination Week	3	11 May 2009	29 May 2009
End of Semester Break	7	30 May 2009	19 July 2009

JANUARY 2009 SEMESTER (FOUNDATION)

PARTICULARS	NO. OF WEEKS	DATE	
		START	ENDS
Registration and Orientation of New Students	1	10 Jan 2009	18 Jan 2009
Registration of Existing Students	1 day	18 Jan 2009	
Lecture	9	19 Jan 2009	20 March 2009
Mid-Semester Break	1	21 March 2009	29 March 2009
Lecture	7	30 March 2009	15 May 2009
Study Week	1	16 May 2009	24 May 2009
Examination Week	2	25 May 2009	5 June 2009
End of Semester Break	6	6 June 2009	19 July 2009

JULY 2009 SEMESTER (UNDERGRADUATE)

PARTICULARS	NO. OF WEEKS	DATE	
		START	ENDS
Registration and Orientation of New Students	1	11 July 2009	19 July 2009
Registration of Existing Students	1 day	19 July 2009	
Lecture	9	20 July 2009	18 Sept 2009
Mid-Semester Break	1	19 Sept 2009	29 Sept 2009
Lecture	5	30 Sept 2009	30 Oct 2009
Study Week	1	31 Oct 2009	8 Nov 2009
Examination Week	3	9 Nov 2009	27 Nov 2009
End of Semester Break	7	28 Nov 2009	17 Jan 2010

JULY 2009 SEMESTER (FOUNDATION)

PARTICULARS	NO. OF WEEKS	DATE	
		START	ENDS
Registration and Orientation of New Students	1	11 July 2009	19 July 2009
Registration of Existing Students	1 day	19 July 2009	
Lecture	9	20 July 2009	18 Sept 2009
Mid-Semester Break	1	19 Sept 2009	29 Sept 2009
Lecture	7	30 Sept 2009	13 Nov 2009
Study Week	1	14 Nov 2009	22 Nov 2009
Examination Week	2	23 Nov 2009	4 Dec 2009
End of Semester Break	6	5 Dec 2009	17 Jan 2010

INDUSTRIAL INTERNSHIP TRAINING PROGRAM (IITP) SCHEDULE

SEMESTER	NO. OF WEEKS	START	END
IITP July 2008 Semester	32	2 Jun 2008	9 Jan 2009
IITP January 2009 Semester	32	1 Dec 2008	10 Jul 2009
IITP July 2009 Semester	32	1 Jun 2009	8 Jan 2010
IITP January 2010 Semester	32	30 Nov 2009	9 Jul 2010

***Tentative date for Convocation: 16th August 2009**
*** Industry Advisory Panel Visit: 1st week of February 2009**
*** External Examiners' Visit: 1st week of August 2009**

APPENDIX D: UTP ELECTRCITY LOAD DEMAND FOR JANUARY 2009 SEMESTER

Week No./Max Daily Temperature	0	°C	1	°C	2	°C	3	°C	4
MONDAY	4,882.00	31	5,120.00	33	2,932.00	32	5,204.00	33	3756
TUESDAY	5,036.00	33	5,396.00	33	2,752.00	32	4,080.00	33	5524
WEDNESDAY	5,092.00	33	5,414.00	32	5,348.00	33	5,376.00	32	5548
THURSDAY	4,548.00	32	5,382.00	31	5,662.00	33	5,256.00	33	5584
FRIDAY	5,276.00	35	5,140.00	32	5,156.00	30	5,124.00	33	5900
SATURDAY	2,956.00	33	3,638.00	31	4,386.00	32	3,676.00	35	4460
SUNDAY	3,236.00	27	2,488.00	31	3,068.00	33	3,256.00	33	3088
Average Weekday Load (kW)	4966.8		5290.4		4370		5008		5262.4
Average Weekday Temperature		32.8		32.2		32		32.8	
Saturday's Temperature (°C)		33		31		32		35	
Sunday's Temperature (°C)		27		31		33		33	

Week No./Max Daily Temperature	°C	5	°C	6	°C	7	°C	8
MONDAY	35	5,764.00	32	5,208.00	30	5,520.00	27	2,692.00
TUESDAY	33	5,748.00	31	5,308.00	32	5,392.00	32	5,524.00
WEDNESDAY	35	5,760.00	31	5,404.00	33	5,804.00	31	5,820.00
THURSDAY	35	5,652.00	32	5,292.00	30	5,496.00	32	5,364.00
FRIDAY	35	5,464.00	32	5,172.00	33	5,636.00	31	5,288.00
SATURDAY	33	4,004.00	33	3,740.00	31	3,908.00	32	4,052.00
SUNDAY	30	3,628.00	32	3,592.00	32	3,300.00	32	3,232.00
Average Weekday Load (kW)		5677.6		5276.8		5569.6		4937.6
Average Weekday Temperature	34.6		31.6		31.6		30.6	
Saturday's Temperature (°C)	33		33		31		32	
Sunday's Temperature (°C)	30		32		32		32	

Week No./Max Daily Temperature	°C	9	°C	10	°C	11	°C	12
MONDAY	32	5,712.00	35	4,912.00	32	5,448.00	31	5,572.00
TUESDAY	31	5,680.00	31	4,928.00	32	5,524.00	30	5,848.00
WEDNESDAY	32	5,412.00	35	4,772.00	35	5,448.00	32	5,824.00
THURSDAY	33	5,372.00	31	4,700.00	33	5,412.00	33	5,560.00
FRIDAY	33	5,484.00	31	4,364.00	32	5,828.00	31	5,456.00
SATURDAY	33	3,220.00	33	3,104.00	32	4,192.00	32	4,068.00
SUNDAY	32	2,420.00	33	2,996.00	33	3,336.00	33	4,232.00
Average Weekday Load (kW)		5532		4735.2		5532		5652
Average Weekday Temperature	32.2		32.6		32.8		31.4	
Saturday's Temperature (°C)	33		33		32		32	
Sunday's Temperature (°C)	32		33		33		33	

Week No./Max Daily Temperature	°C	13	°C	14	°C	15	°C	16
MONDAY	32	5,932.00	35	3440	35	5632	32	5,204.00
TUESDAY	33	6,020.00	30	5392	35	5568	32	5,164.00
WEDNESDAY	28	5,516.00	35	5772	33	7414	33	5,304.00
THURSDAY	31	5,516.00	35	6024	33	5416	32	5,496.00
FRIDAY	35	5,872.00	32	5996	35	3496	33	3,272.00
SATURDAY	35	3,780.00	33	3816	31	3160	33	3,200.00
SUNDAY	30	2,944.00	33	3496	30	2988	33	3,528.00
Average Weekday Load (kW)		5771.2		5324.8		5505.2		4888
Average Weekday Temperature	31.8		33.4		34.2		32.4	
Saturday's Temperature (°C)	35		33		31		33	
Sunday's Temperature (°C)	30		33		30		33	

Week No./Max Daily Temperature	°C°C	17	°C	18	°C	19	°C	20
MONDAY	32	5,932.00	31	5,480.00	35	5,956.00	32	5248
TUESDAY	35	5,712.00	33	5,652.00	30	5,244.00	32	4644
WEDNESDAY	33	6,020.00	33	5,744.00	32	5,376.00	32	5088
THURSDAY	30	5,608.00	32	5,748.00	32	5,400.00	31	5000
FRIDAY	32	5,748.00	32	5,480.00	32	5,192.00	33	2800
SATURDAY	32	4,388.00	33	3,756.00	31	3,036.00	35	3088
SUNDAY	32	3,552.00	35	3,512.00	33	2,936.00	33	2720
Average Weekday Load (kW)		5804		5620.8		5433.6		4556
Average Weekday Temperature	32.4		32.2		32.2		32	
Saturday's Temperature (°C)	32		33		31		35	
Sunday's Temperature (°C)	32		35		33		33	

Week No./Max Daily Temperature	°C	21	°C	22	°C	23	°C	24
MONDAY	33	5144	33	4488	32	4680	32	4468
TUESDAY	35	5124	32	4992	33	4568	33	4144
WEDNESDAY	33	5312	35	4796	31	4936	32	4072
THURSDAY	35	4776	32	5942	33	4834	30	4116
FRIDAY	35	4780	35	4646	31	4576	32	4440
SATURDAY	33	2772	33	2964	32	2600	33	3348
SUNDAY	32	2772	32	2308	31	2296	32	2516
Average Weekday Load (kW)		5027.2		4972.8		4718.8		4248
Average Weekday Temperature	34.2		33.4		32		31.8	
Saturday's Temperature (°C)	33		33		32		33	
Sunday's Temperature (°C)	32		32		31		32	

APPENDIX E: PUBLIC HOLIDAYS IN MALAYSIA 2009

Date	Holiday	Kuala Lumpur	Labuan	Putrajaya	Johor	Kedah	Kelantan	Malacca	Negeri Sembilan	Pahang	Perak	Perlis	Penang	Sabah	Sarawak	Selangor	Terengganu
10 Jan	Awal Muharram (Maal Hijrah)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7 Feb	Chinese New Year	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8 Feb	Chinese New Year (2nd Day)	X	X	X	X	X		X	X	X	X	X	X	X	X	X	
20 Mar	Prophet Muhammad's Birthday (Maulidur Rasul)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1 May	Labour Day	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
19 May	Wesak Day	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7 Jun	Agong's Birthday	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
31 Aug	National Day	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1 Oct	Hari Raya Puasa *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2 Oct	Hari Raya Puasa *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

27 Oct	Deepavali	X		X	X	X	X	X	X	X	X	X	X	X		X	X
8 Dec	Hari Raya Haji *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9 Dec	Hari Raya Haji (2nd Day) *						X										X
25 Dec	Christmas	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
29 Dec	Awal Muharram (Maal Hijrah)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

STATE HOLIDAYS OF YEAR 2009

Date	Holiday	Kuala Lumpur	Labuan	Putrajaya	Johor	Kedah	Kelantan	Malacca	Negeri Sembilan	Pahang	Perak	Perlis	Penang	Sabah	Sarawak	Selangor	Terengganu
1 Jan	New Year	X	X	X				X	X	X	X		X	X	X	X	
20 Jan	Sultan of Kedah's Birthday					X											
23 Jan	Thaipusam				X				X		X		X			X	
1 Feb	Federal Territory Day	X	X	X													
4 Mar	Anniversary of Installation of Sultan of Terengganu																X
21 Mar	Good Friday													X	X		
30 Mar	Sultan of Kelantan's Birthday						X										
31 Mar	Sultan of Kelantan's Birthday						X										
8 Apr	Sultan of Johor's Birthday				X												
15 Apr	Declaration of Malacca as a Historical City							X									
19 Apr	Sultan of Perak's Birthday										X						
7 May	Hari Hol Pahang									X							
17 May	Raja Perlis' Birthday											X					
30 May	Harvest Festival		X											X			
31 May	Harvest Festival		X											X			
1 Jun	Hari Gawai														X		
2 Jun	Hari Gawai														X		

9 Jul	Hari Hol Johor				X												
12 Jul	Penang Governor's Birthday												X				
19 Jul	Yang di-Pertuan Besar Negeri Sembilan's Birthday								X								
20 Jul	Sultan of Terengganu's Birthday																X
30 Jul	Israk & Mikraj					X			X			X					
1 Sep	Awal Ramadan *				X	X		X									
13 Sep	Sarawak Governor's Birthday														X		
16 Sep	Sabah Governor's Birthday													X			
17 Sep	Nuzul Al-Quran						X			X	X	X	X			X	X
11 Oct	Malacca Governor's Birthday							X									
24 Oct	Sultan of Pahang's Birthday									X							
11 Dec	Sultan of Selangor's Birthday															X	

APPENDIX F: GANTT CHART for FYP 2

No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Project Work- Fuzzy Logic Revision,Data collection and analyzing	■	■	■					MID SEMESTER							
2	Submission of Progress Report 1				●											
3	Project Work Continue- Model Improvement				■	■	■	■								
4	Submission of Progress Report 2									●						
5	Seminar (compulsory)										■	■	■			
5	Project work continue- Model Improvement									■	■	■	■			
6	Poster Exhibition											●				
7	Submission of Dissertation (soft bound)													●		
8	Oral Presentation														●	
9	Submission of Project Dissertation (Hard Bound)															●

● Suggested milestone

■ Process